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Analysis of Airborne Magnetometer Data from Tests at Isleta Pueblo, New Mexico, February 2003

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I N S T I T U T E   F O R   D E F E N S E   A N A L Y S E S

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PREFACE

This document was prepared under a task titled "ESTCP/SERDP: Assessment of Traditional and Emerging Approaches to the Detection and Identification of Surface and Buried Unexploded Ordnance." The authors would like to thank Drs. Jeff Marqusee and Anne Andrews of the ESTCP/SERDP Program Office for their guidance in carrying out this analysis and for their careful reviews of the technical memorandum that preceded this document and of the draft version of this report. We would also like to express our gratitude to the Oak Ridge National Laboratory and Naval Research Laboratory teams for their cooperation in this effort. Finally, we would like to thank Mr. Jeff Fairbanks of HydroGeoLogic, Inc., who supports the Program Office and who helped enormously in dig list generation and in sorting, managing and understanding the data collected in the Isleta testing.

CONTENTS

TABLES

FIGURES

EXECUTIVE SUMMARY

INTRODUCTION

In February 2003, the *Naval Research Laboratory* (NRL) *Airborne Multi-sensor Towed Array Detection System* (aMTADS) and the *Oak Ridge National Laboratory* (ORNL) *Airborne Geophysics System* (ORAGS) magnetometer systems surveyed 600 hectares of a former practice bombing range at Isleta Pueblo, New Mexico. The NRL ground-based *Multi-sensor Towed Array Detection System* (gMTADS) provided baseline data for comparison. All three systems employed cesium-vapor, total-field magnetometers (Geometrics Model 822 for the two MTADS and Scintrex CS-2 for ORAGS) but differed in platform setup and data processing.

- gMTADS employed a low-magnetic-signature vehicle to tow a linear array of magnetometers. It had the smallest sensor-to-sensor (25 cm) and target-to-sensor separation (nominal sensor height above ground was also 25 cm).
- Both aMTADS and ORAGS employed similar Bell helicopter models, but aMTADS mounted seven sensors on a forward boom with 1.5 m spacing, whereas ORAGS deployed four sensors on a forward boom and four on a mid-ship boom with 1.75 m cross-track spacing. Both helicopters attempted to fly at a nominal altitude of about 2 m.
- Oak Ridge used automatic target recognition algorithms to process the magnetometer data and classify targets. NRL relied on human judgment aided by computer-implemented, dipole-fit routines;

PROCEDURE

The Institute for Defense Analyses calculated probability of detection, background alarm rates, and other appropriate statistics for the NRL gMTADS, NRL aMTADS, and ORNL ORAGS systems through three major methodologies.

- 112 ordnance items comprising 60 mm and 81 mm mortars, 105 mm shells, and 2.75 in. rockets were buried among existing clutter and UXO in the former training range.

- A dig list of unknown items was generated using gMTADS data, and the unknown items were subsequently dug and identified.
- A dig list of unknown items was generated using data from the airborne systems, and the unknown items were subsequently dug and identified.

Each system operator provided an ordered list of detections and assigned each detection a "confidence of ordnance" ranging from 1 being "high confidence UXO" to 6 being "high confidence clutter."

The criteria for the 1–6 classification were determined by each operator utilizing metrics considered appropriate for his system. The digging of detected unknown items provided additional statistics, which were analyzed separately from the seeded ordnance. The ability of the three systems to successfully detect *and* identify the buried and dug ordnance was then measured and appropriate receiver operating characteristics (ROC) curves calculated.

FINDINGS AND CONCLUSIONS

A priori consideration of the hardware similarity between aMTADS and ORAGS would suggest similar overall performance. However, in spite of that similarity, their differing platform setup and data-processing methods produced different results, with aMTADS performing better than ORAGS in testing against emplaced ordnance. As expected, the vehicle-towed system outperformed both airborne systems in the areas that it surveyed. For both airborne systems, the detection performance demonstrates that the ~1/(distance)^3 dependence of the signal strength converts the increased distance (compared with a ground-based system) between the target and the sensor into a challenging problem. Based on the results, we make the following observations:

- Both systems, with their current, associated, data-processing techniques, are capable of reliably detecting areas of high clutter and potential UXO density.
- If maximum sensitivity is desired, it is important that an airborne system design allow very low-level flight in areas where that is possible.
- While the ground-based system detected every emplaced ordnance item within its actual survey area, neither helicopter-based system demonstrated reliable detection of small ordnance (25% probability of detection or less against 60 mm mortar rounds). In addition, aMTADS detected only three-fourths of the 105 mm rounds and ORAGS detected less than one-third of those rounds. Those detection statistics would argue against the use of the

helicopter systems for individual UXO detection, except for large ordnance in benign topography, land cover, and magnetic background situations.

- aMTADS's consistent ability to more accurately determine target position (33 cm average radial error on the emplaced targets vs. 97 cm for ORAGS) improves target reacquisition performance and reduces ambiguity opportunities.
- Current automated target detection and recognition algorithms do not appear to be robust or accurate enough to replace the use of human judgment in interpreting the magnetometer data and determining which targets are likely UXO.

I. INTRODUCTION

Under Contract DASW01-04-C-0003, Task AM-2-1528, the Institute for Defense Analyses (IDA) supports the Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP) with analyses of emerging technologies in the unexploded ordnance (UXO) detection and discrimination areas and with independent evaluations of system performance in technology demonstrations. The purpose of this document is to provide the results of IDA's evaluation of data collected by the Naval Research Laboratory (NRL) airborne and ground-based magnetometer systems and the Oak Ridge National Laboratory (ORNL) airborne magnetometer system in testing conducted at Isleta Pueblo, New Mexico, during February 2003. We first give a brief description of the test areas and the data collected. We then summarize the detailed analysis and provide data examples to allow the reader to understand the basis upon which findings and conclusions are drawn.

A. ISLETA TEST SITE

The area of Isleta Pueblo chosen for survey is a former practice bombing range for Kirtland AFB that was in active use from 1956–1961. Previous surveys and surface-clearance activities had identified a "bull's-eye" area with a large concentration of ordnance debris. Figures 1 and 2 provide a residual magnetic field map and an analytic signal map of the area, where the bull's-eye is clearly visible. Figure 3 is a topographic map with the individual survey areas indicated by boxes. All three systems surveyed approximately 20 hectares in the vicinity of the bull's-eye area (indicated as the vehicular area on Figure 3), but the bull's-eye area itself was excluded from scoring because the debris density was considered too high for unambiguous association of dug items with specific detections or for accurate discrimination. A total of 112 ordnance items comprising 60 mm and 81 mm mortars, 105 mm shells, and 2.75-inch rockets were buried within the joint survey area. Both the NRL airborne Multi-Sensor Towed Array Detection System (aMTADS) and the Oak Ridge Airborne Geophysics System (ORAGS) surveyed a total area of about 600 hectares, including all of the area around the bull's-eye that included the seeded items. Post-survey digs were completed at more than 400 declared detection locations to provide additional truth data for scoring. For the purpose of this analysis, we have divided the site into two areas, one where all three systems conducted surveys and one where only the two airborne systems surveyed. Unknown item dig lists were produced for both areas. Details on how dig items were selected are provided in the data description section.

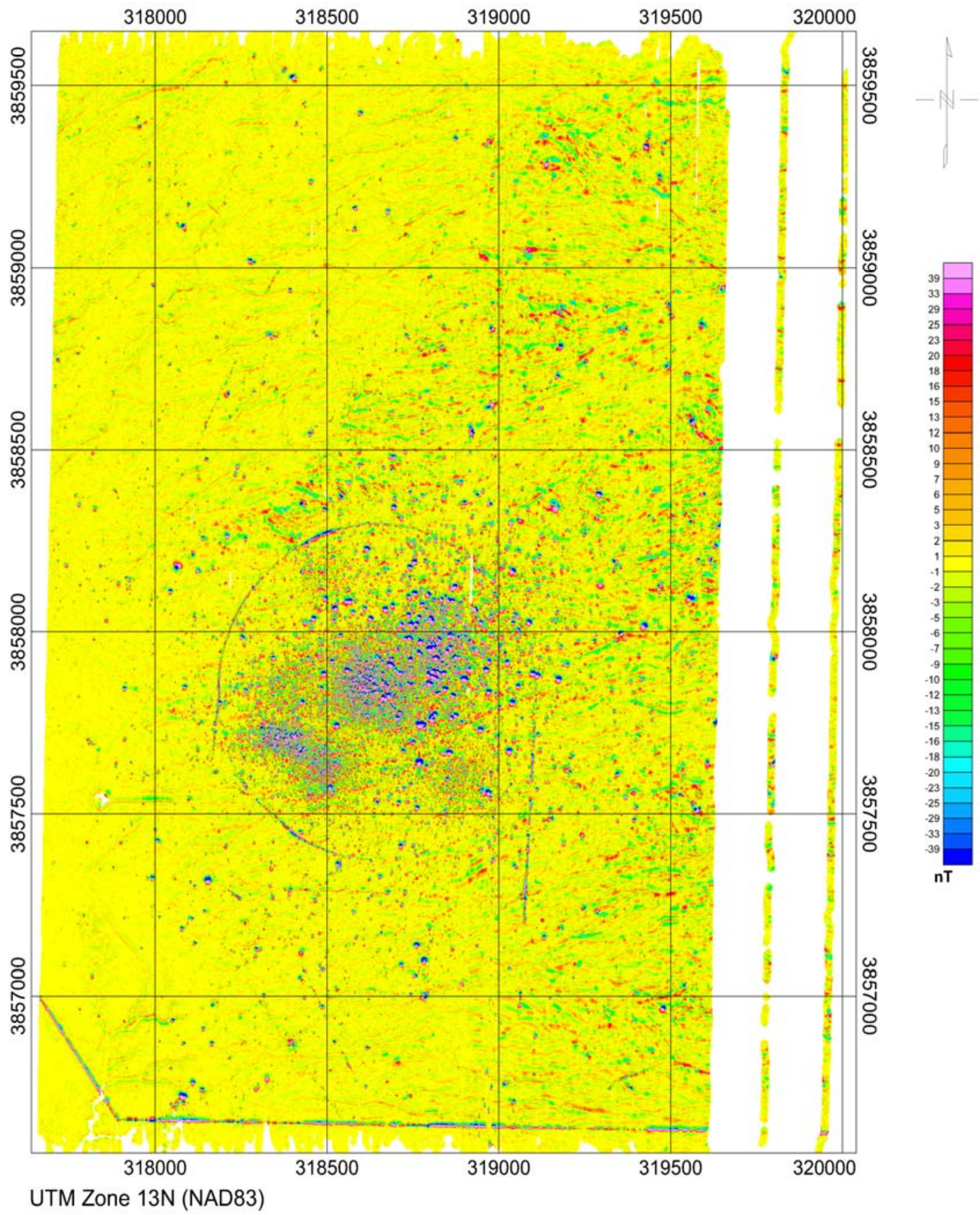


Figure 1. aMTADS Residual Magnetic Field Map of the Isleta Survey Area

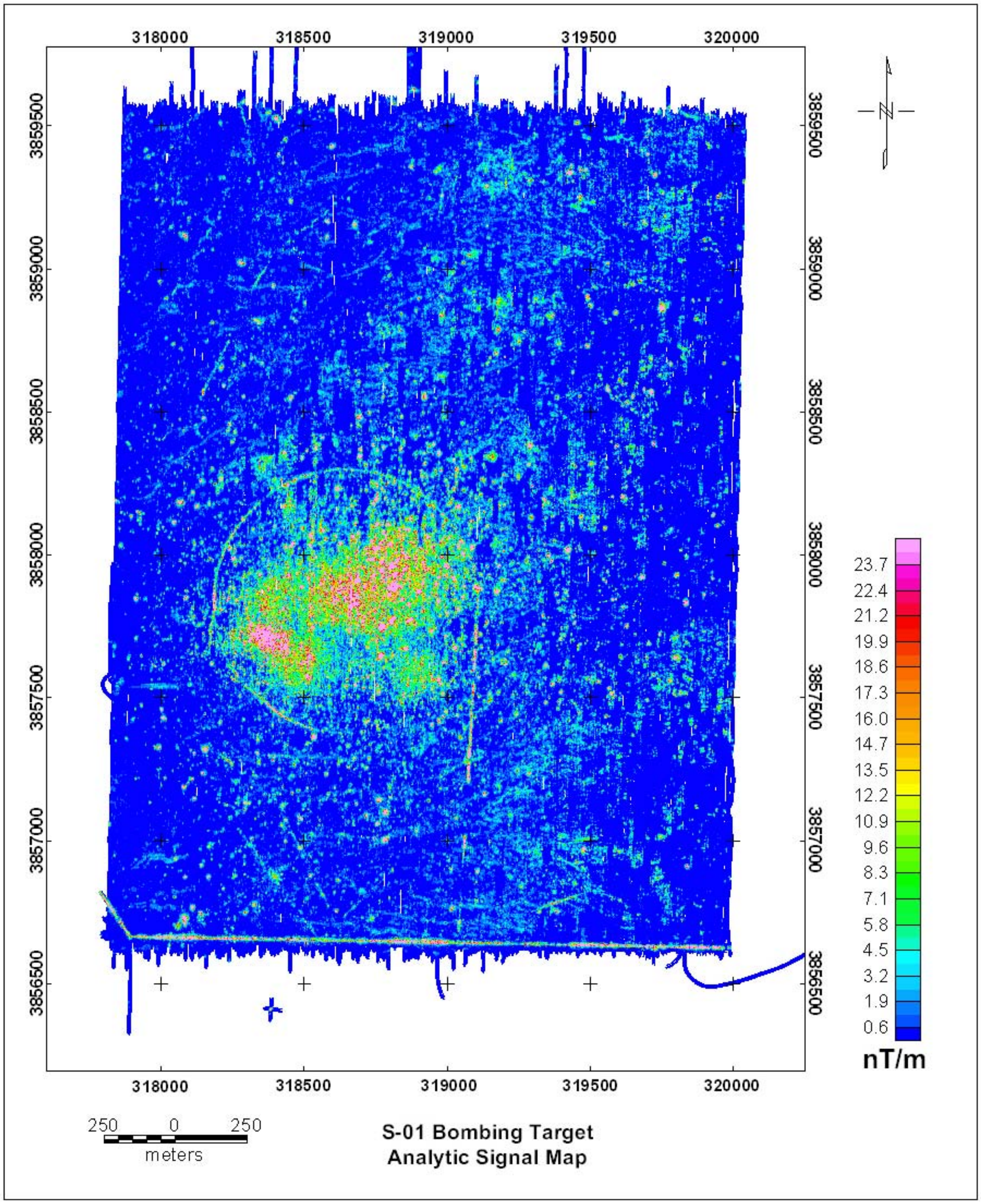


Figure 2. ORAGS Analytic Signal Map of the Isleta Survey Area

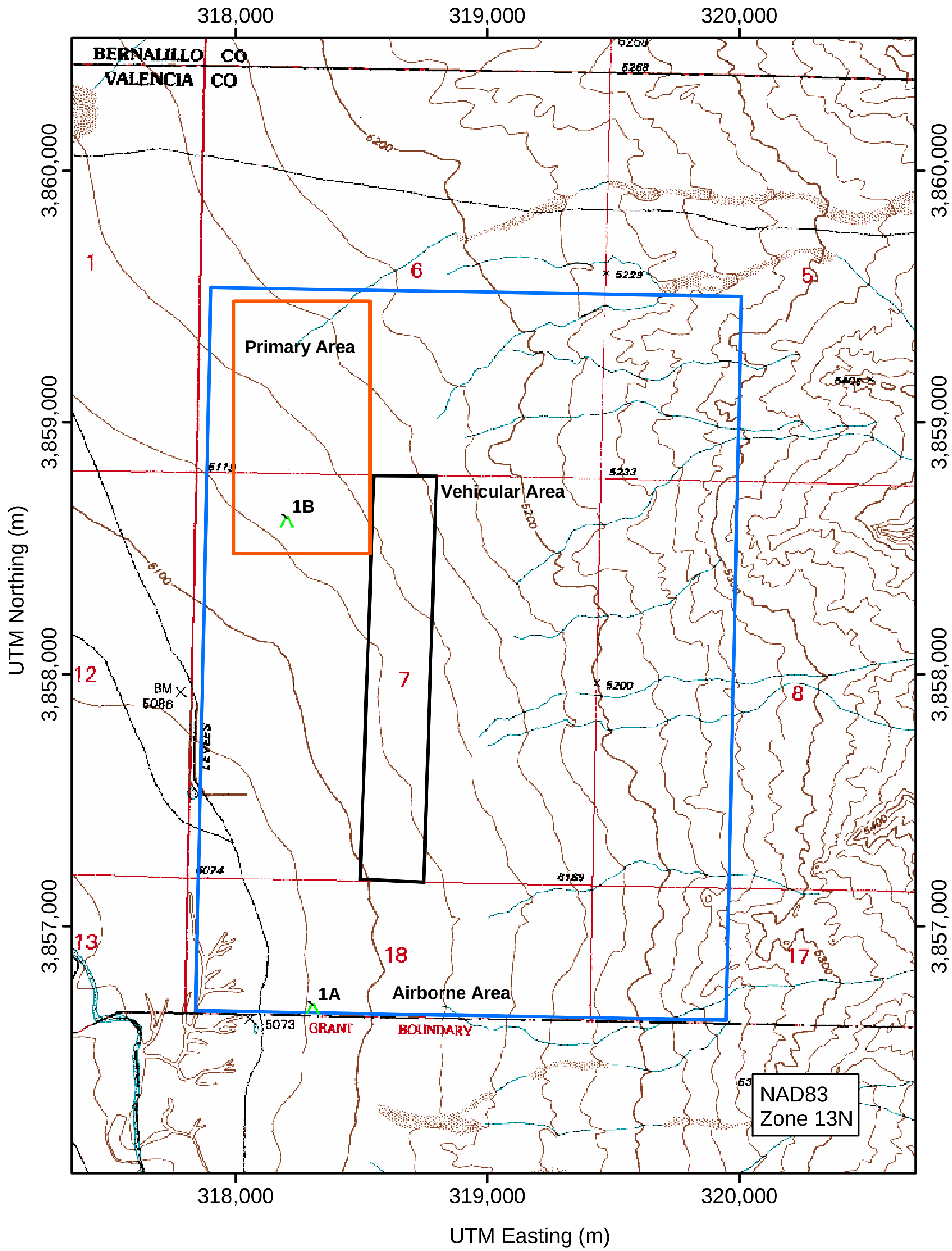


Figure 3. Topographic Map of the Isleta Survey Area with the Various Survey Areas Marked by Boxes [1]

B. SENSOR SYSTEM DESCRIPTIONS [1, 2]

Three magnetometer systems deployed to Isleta to collect anomaly data. The primary reason for the testing was to evaluate the performance of two airborne systems that are capable of providing rapid, wide-area surveys in benign topography/ground cover regions. The NRL vehicle-towed MTADS, here denoted gMTADS and shown in Figure 4, was used as the "reference" collection platform for a part of the area because it has better sensitivity than the airborne systems. The gMTADS employs eight cesium-vapor, total-field magnetometers spaced 25 cm in the across-track direction. The sensor sample rate is 50 Hz, which, combined with a typical vehicle speed of 3 m/s, results in a 6 cm down-range sample spacing. The major advantage of the vehicle-towed system, however, is its nominal 25 cm sensor-to-ground standoff. With the static magnetic signal strength falling off at a $1/(\text{distance})^3$ rate, the much smaller sensor-to-target separation for the gMTADS translates to much stronger signal strengths. The lesser separation also results in smaller individual sensor footprints and thus in less area averaging of the detected signal.

Figure 4. NRL Multi-Sensor Towed Array Detection System (gMTADS)

The original test plan called for the gMTADS to survey 40 hectares in the vicinity of the bull's-eye. A system mechanical breakdown during the survey resulted in coverage of just over half the planned area. Because the area not covered included some of the emplaced items, scoring of the gMTADS takes into account only the actual area that it covered.

Two helicopter-borne sensor arrays were demonstrated in the tests at Isleta. Each was carried on a similar Bell 206L Long Ranger helicopter. The arrays employed cesium-vapor, total field magnetometers (Geometrics Model 822 for aMTADS and Scintrex CS-2 for ORAGS) mounted on nonmetallic booms and differential GPS systems to provide accurate position data for anomaly location and for discrimination algorithm inversion. The arrays, navigation instrumentation, and data processing differed in a number of details, however.

ORAGS, developed by ORNL and shown in Figure 5, deployed the magnetometer sensors on the "Arrowhead" array. This array included four outboard magnetometers, two on each side of the aircraft, mounted on an amidships horizontal boom, and four magnetometers spaced horizontally on a boom forward of the helicopter nose. Magnetometer-to-magnetometer spacing was 1.75 m. While this arrangement provided a very wide array (12.25 m array width and potentially a 14 m survey swath), the fore-aft spacing of the sensors and the wide lateral spread complicates signal leveling. The ORAGS data-collection system sampled at a 1,200 Hz rate, but commonly the data are downsampled to 120 Hz for analysis. In the data-analysis phase, the ORNL team created an analytic signal map and then employed an automated threshold exceedence algorithm to pick peaks for analysis. Two automatic algorithms were used for detection and classification analysis of the Isleta data.

Figure 5. Oak Ridge Airborne Geophysics System (ORAGS)

The airborne version of the MTADS, which we designate aMTADS and show in Figure 6, is an outgrowth of the vehicle-towed system. It employed seven magnetometers on a single horizontal boom in front of the helicopter nose. Magnetometer spacing was

1.5 m (9 m array width and potentially, a 10.5 m swath), and sensor sampling was accomplished at 100 Hz. The NRL team handpicked anomalies from the total field maps and then applied a dipole-fit analysis in selecting and classifying targets.

Figure 6. NRL Airborne MTADS (aMTADS)

Both aircraft attempt to maintain an altitude of a few meters above the ground and a forward speed of around 20 m/s (aMTADS operated at about 10 m/s at Isleta). The 20 m/s speed results in nominal down-track sample spacings of 15–20 cm, which is much finer than the cross-track sampling for either magnetometer array. Cross-track sampling finer than the 1.5 m or 1.75 m sensor spacing can be provided by multiple passes, or overlapping passes, at the expense of area coverage rate. NRL typically flies 7 m lane spacings with a nominal 10.5 m array footprint, to prevent holes in coverage, while ORNL uses 12 m lane spacings, for their 14 m array footprint.

C. DATA DESCRIPTION

IDA received several basic types of data for this system performance evaluation effort. The first was a list of ordnance buried within the three-system section by personnel from the Army Engineering R&D Center (ERDC), Vicksburg, Miss. There was a coordinate conversion problem in the initial list of calibration objects provided by ERDC to the demonstrators, and both teams flew the calibration lanes based on the incorrect coordinates. Errors in calibration target position varied from about 5 m to 25 m. ERDC subsequently corrected the list, and the corrected list was provided to the demonstrators before dig lists were submitted. ERDC rechecked the coordinates of all the buried seed items when they were recovered (calibration and blind area), and maximum differences between pre-burial and post-dig position data were typically no greater than a few centimeters. The second set of data was detection lists from the three participating systems. Although each list provided ancillary information, the important data items for the analysis were the estimated position of each anomaly and the likelihood that the anomaly represented UXO. The standard six-category division of UXO likelihood was used, where category 1 represents most likely UXO and category 6 represents most likely clutter.

An ESTCP, HydroGeoLogic Inc. (ESTCP support contractor), and IDA team used the system detection lists to generate separate dig lists for the area covered by all three systems and for the airborne-only area. The three-system list contained all gMTADS category 1 and 2 detections plus some large items from the aMTADS survey assessed to be of interest. From that dig list, a total of 272 items were dug and categorized as intact ordnance, ordnance-related scrap, non-ordnance-related clutter, geology, or as an empty hole. In the area covered by only the airborne systems, all category 1 and 2 items for both systems were on the dig list. The dig resulted in 161 items for scoring.

For the three-systems area, gMTADS coordinates were provided to the dig team because of their tighter error statistics. For the airborne-only area, there were two generic cases. Anomalies on one list either had a match on the other list or did not (i.e., the position for an anomaly on the other list either fell within a 1.5 m halo or did not). For the no-match case, the dig team received the coordinates from the anomaly list on which the target appeared. Where items had a match, the aMTADS (rather than ORAGS) coordinates were used, again because of that system's better geolocation statistics against emplaced ordnance. While there was a possibility that choice could bias results, use of the most accurate available location data was felt essential in the heavily cluttered environment at Isleta. Since in both cases demonstrators were scored against the actual dug locations of the recovered items, and not against the coordinates provided in the dig lists, this procedure fairly measures the probability that either system detected a particular item that was dug.

At ESTCP direction, NRL was required to submit an aMTADS dig list for the three-system area before data collection by gMTADS. Weather delays in collecting the aMTADS data compressed the analysis schedule to such an extent that the NRL team delivered an incomplete analysis, principally for areas on the western end of the survey. After noting that analysis had not been completed for important areas of the site, ESTCP directed that NRL submit a second, more complete, detection list. IDA denoted that list "aMTADSE" for aMTADS-extended and used that list for the scoring.

Finally, after IDA's production of a draft memorandum on the demonstration results, both teams provided position and altitude data for portions of the testing to allow an analysis of the speeds and altitudes flown by the two systems. Those data were used to assess how the way in which the systems were operated might have affected performance.

II. ANALYSIS

A. OVERVIEW

IDA has assessed detection performance and location-error statistics for the emplaced ordnance, for the dug items in the area covered by all three systems, and for the dug items in an area covered only by the airborne systems (denoted the Primary Area in Figure 3). We have also assessed discrimination performance, based on the three-system dig results. Discrimination performance is discussed in section II.C and in Appendix C.

One immediate question in scoring performance concerns the size and shape of the area around an item within which a declaration is counted as a detection. For this analysis, we use a circular area, denote its perimeter as the detection "halo," and define it in terms of the radial distance from the center of the target. From a clearance point of view, the more accurately a system locates an item to be dug, the more efficiently it can be reacquired for digging, and the less likely it is to be confused with a nearby item. If discrimination improves to the point that only items judged likely to be ordnance are excavated, accurate location capability will become even more important. On the other hand, to fully assess system performance, the radius should be large enough to adequately represent system-detection capabilities.

To assess halo radii for analysis, we looked at detection results for the two airborne systems as a function of halo area. Because the percentage of total detections made by chance begins to rise rapidly as the total area of detection calls becomes a significant percentage of the survey area, a pure detection analysis is necessarily incomplete. Reference 3 contains a development that provides an estimate of "true" and "chance" detections based on the survey area, halo, total number of declarations, and total number of detections. Appendix A provides a brief explanation of the analysis and contains the resulting equations for true and chance detections. If we assume a detection system exhibits random, zero-mean, location errors, the curve for true detections would be expected to flatten out as system location error limits are reached and additional detections became all chance detections. Figure 7 provides such a set of curves for the Isleta emplaced ordnance. We have plotted the probability of detection (Pd) for the total number of detections for each airborne system; the "true" Pd based on the chance detection analysis of Appendix A; and the percentage of the total survey area each system's declarations would have covered for that halo, ignoring overlap and the area outside the boundaries of the survey area.

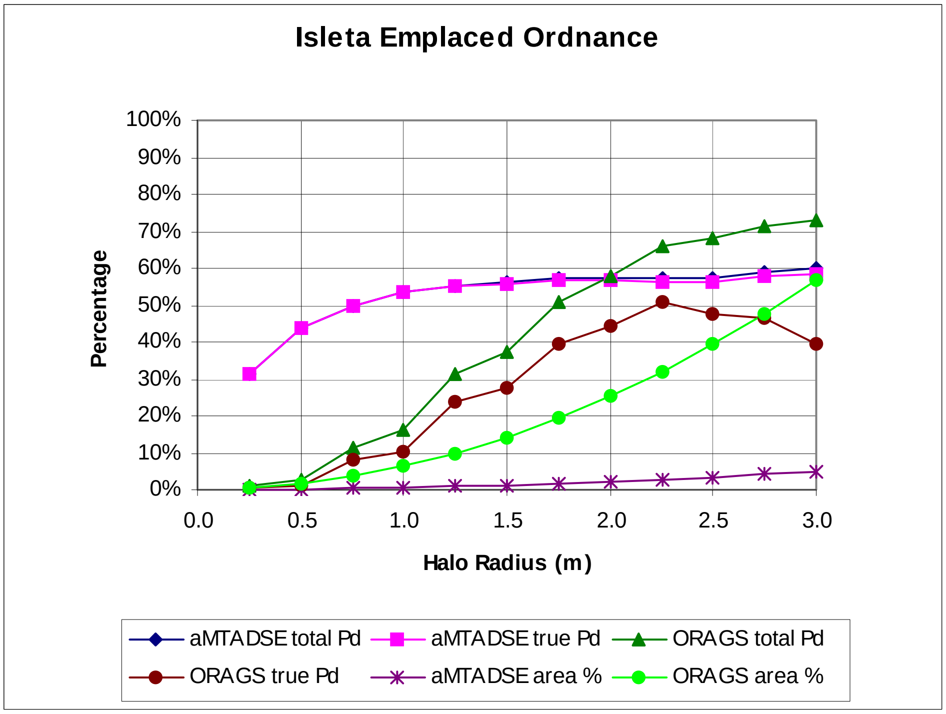


Figure 7. Pd vs. Halo Radius for the Isleta Emplaced Ordnance

Note that the aMTADSE "true" Pd curve behaves as expected, flattening out between a 1.0 and 1.5 m halo. The ORAGS "true" Pd curve, in contrast, increases until it reaches a 2.25 m halo, after which Pd begins to decrease. Clearly, true Pd cannot decrease, and the fact that the curve turns over is an indication that the assumptions of the theory are being violated. At the point of inflection, over one-third of the survey area would be included, assuming no overlap. For such large percentages of area coverage, there will likely be significant overlap of halos. The result of overlap is that actual chance detections do not go up as rapidly as the theory predicts, providing an apparent decrease in true detections.

Obviously, to show aMTADS in its relatively best light we should pick no larger than a 1.0 m halo, and to show ORAGS in its relatively best light we should pick a 2.0 or 2.25 m halo. For most of the results here, we have used the 1.5 m halo as a reasonable compromise, one that does not provide a significant relative advantage to either system and for which the spread between true and total detections is not too great. Where appropriate, however, we present 1.0 m and 2.0 m halo results to emphasize system performance differences as halos change.

B. EMPLACED ITEMS

The ERDC-emplaced items were blind for the gMTADS demonstrators, so gMTADS, as well as ORAGS and aMTADS, was scored for those items. Table 1 provides the number of each emplaced ordnance type detected for a 1.5 m halo. ORAGS and aMTADSE surveyed the entire seeded area and are scored on the total number of items and total area. Because of the mechanical breakdown, gMTADS did not cover the entire seeded area, so its scoring is limited to the items within the boundaries that it surveyed. The totals on which it is scored are reflected in its column in the table.

Table 1. Emplaced Ordnance Detection by Type for a 1.5 m Halo

Ordnance	Total	ORAGS	aMTADSE	gMTADS
2.75 inch	12	7	11	2 of 2
60 mm	20	5	4	6 of 6
81 mm	40	15	19	20 of 21
105 mm	40	15	29	17 of 18
Total	112	42	63	45 of 47

To achieve the detections shown in the table, ORAGS declared 1,937 targets, aMTADSE declared 165 targets, and gMTADS declared 104 targets. Receiver operating characteristic (ROC) curves were produced for each system using the six ordnance likelihood categories. Pd is plotted vs. background alarm rate (in number of alarms per hectare), where the survey area for the airborne systems was 9.63 hectares and for gMTADS was 3.71 hectares. Note that a substantial number of items counted as background alarms are likely ordnance. From the dug items in the three-system area, which were based on the gMTADS high-probability UXO calls (categories 1 and 2), about 24% (65 of 272) of the items recovered were intact ordnance. Thus, we have not labeled the abscissa as false-alarm rate because a substantial number of the background alarms are likely ordnance and not false-alarms at all. Figures 8 and 9 provide the results for the 1.5 m halo and the 1.0 m halo. In going from a 1.5 to 1.0 m halo, gMTADS lost no targets, aMTADSE lost 1 target, and ORAGS lost 24 of 42 targets.

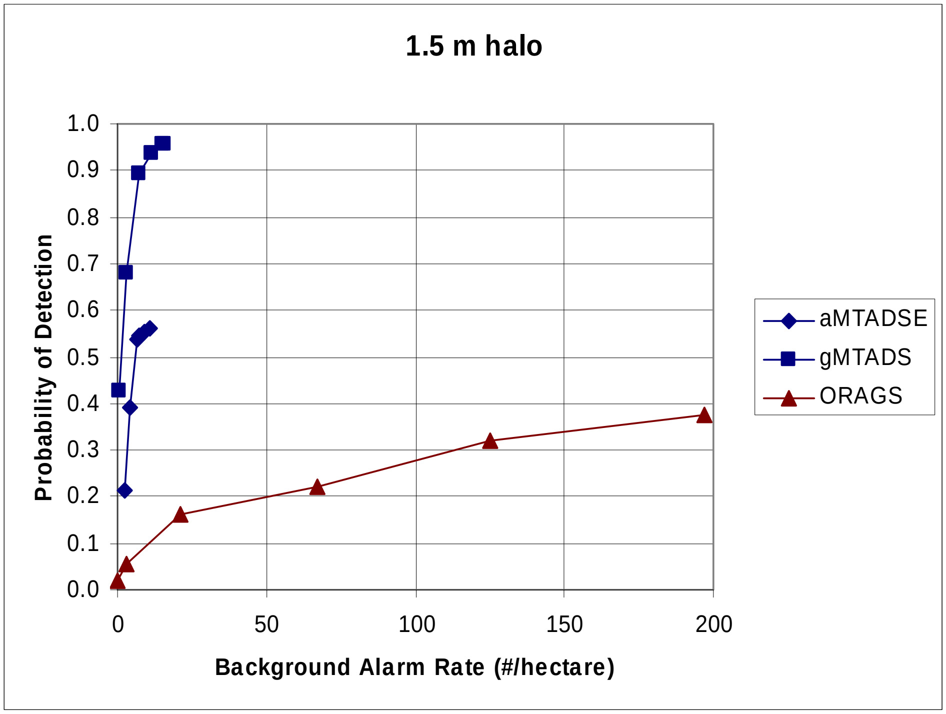


Figure 8. ROC Curve for Isleta Emplaced Items and a 1.5 m Halo Including 60 mm

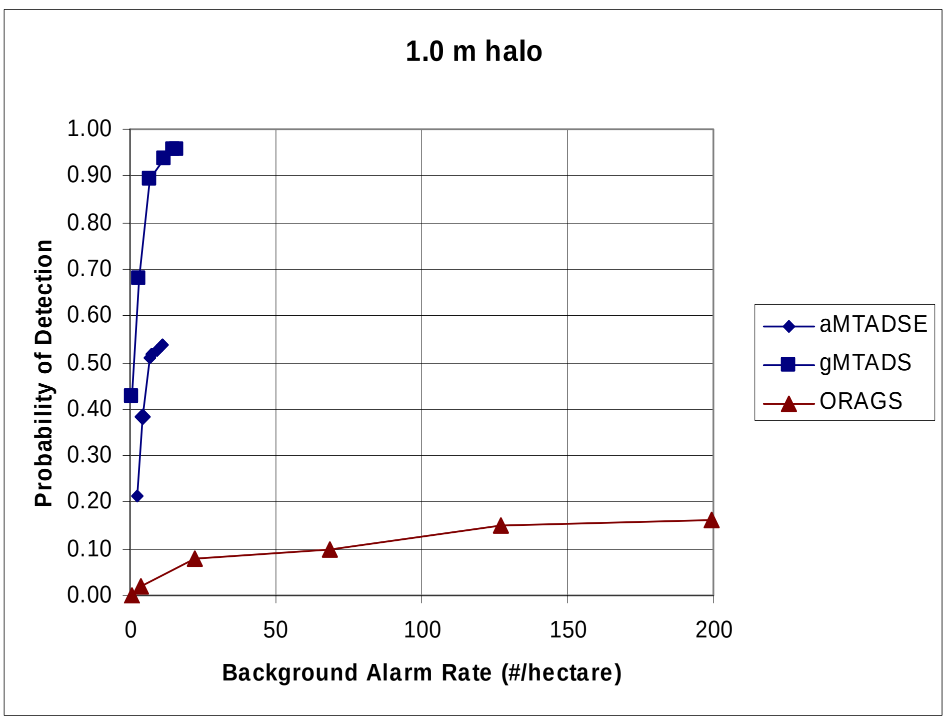


Figure 9. ROC Curve for Isleta Emplaced Items and a 1.0 m Halo Including 60 mm

The airborne systems were not designed to routinely detect ordnance smaller than 81 mm, so similar ROC curves were produced with the 60 mm targets removed from the scoring. Because gMTADS detected all the 60 mm rounds, removing them actually hurt its ROC curve. ORAGS detected 5 of 20 and aMTADSE 4 of 20 emplaced 60 mm, so removing the 60 mm improved their overall Pds almost equally. Figure 10 shows the detection results for the three systems for a 1.5 m halo and the case where 60 mm are not considered. Figure 11 shows the same results for the three systems for a 2.0 m halo.

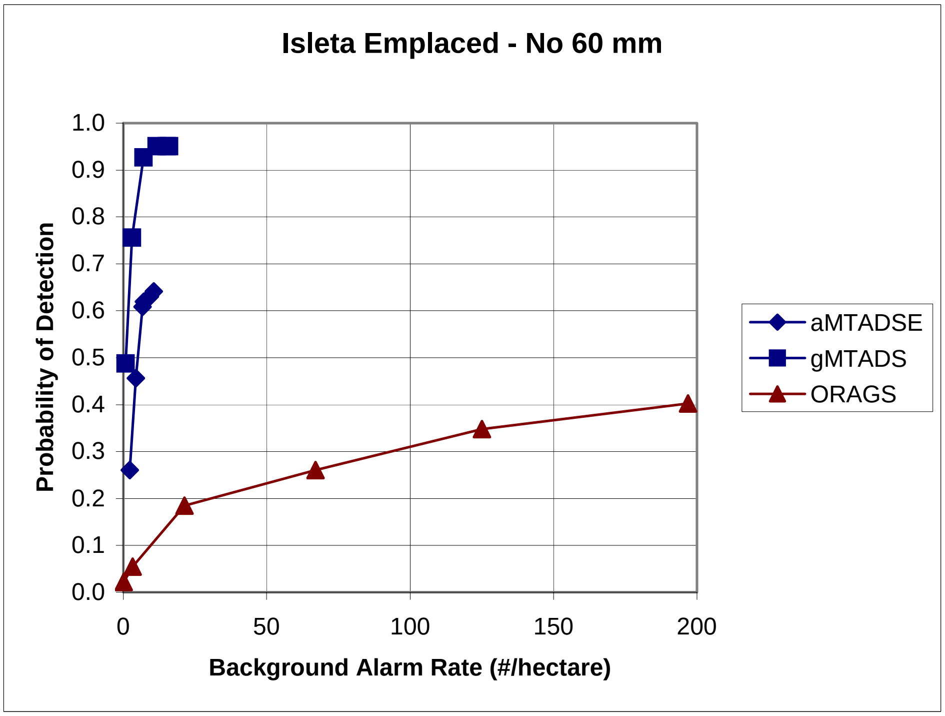


Figure 10. ROC Curves for Isleta Emplaced Ordnance Excluding 60 mm Targets for a 1.5 m Halo

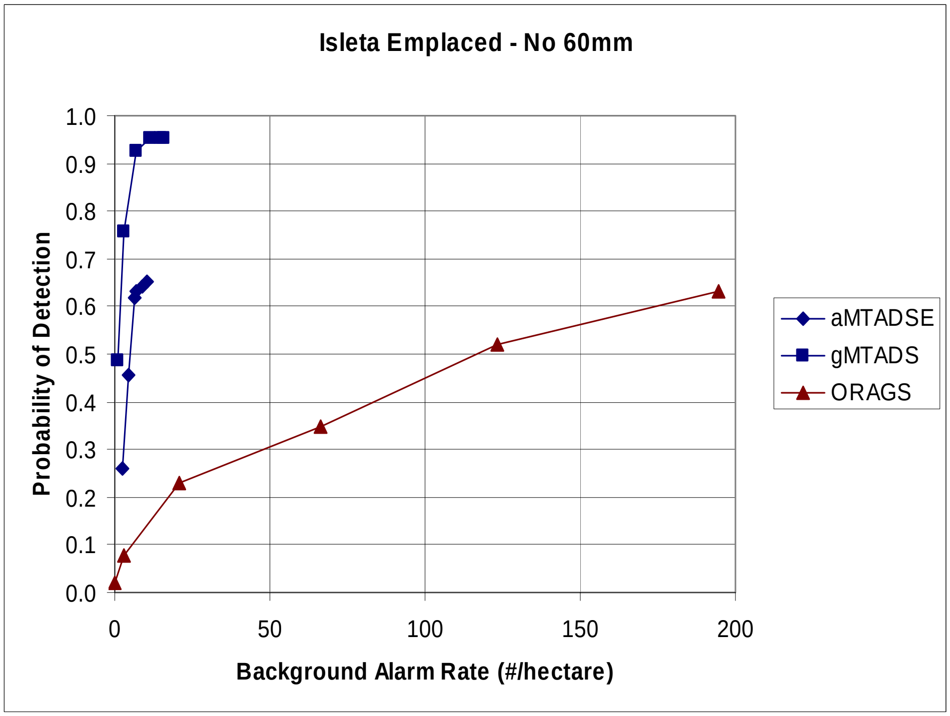


Figure 11. ROC Curves for Isleta Emplaced Ordnance Excluding 60 mm Targets for a 2.0 m Halo

The difference between automatic and manual anomaly selection created a large difference in the number of detection calls between the systems. It is therefore useful to apply the chance detection analysis of Appendix A to determine what part that might have played in the detections. Table 2 shows cumulative true and chance detections based on the 1.5 m halo matches. The formula in Appendix A does not provide integer results, so values are rounded to the nearest whole number. Because of the relatively few total declarations by the two MTADS systems, the analysis indicates that none of the detections provided by those systems were likely chance detections. For ORAGS, a total of only 223 detection calls were made in the first 3 ordnance likelihood categories, and the analysis indicates that 17 of 18 of the matches to emplaced ordnance were likely true detections. Categories 4–6 contain a great majority of the total number of ORAGS detection calls (1,714 of the 1,937), and a substantial number of the ordnance found in those categories were likely chance detections (3 of 7 in category 4, 3 of 11 in category 5, and 4 of 6 in category 6).

Table 2. Cumulative Total and True Detections for the Emplaced Ordnance and 1.5 m Halo

UXO Likelihood	ORAGS detections Total/True	aMTADS detections Total/True	gMTADS detections Total/True
1	2/2	24/24	20/20
2	6/6	44/44	32/32
3	18/17	60/60	42/42
4	25/21	61/61	44/44
5	36/29	62/62	45/45
6	42/31	63/63	45/45

To further explore the results of Table 2, IDA analyzed ORAGS emplaced ordnance detections by ordnance type and UXO likelihood category. Of the five 60 mm mortars detected by ORAGS, one was a category 2, three were category 5, and one was category 6. For the fifteen detected 81 mm mortars, one was a category 3, five were category 4, five were category 5, and four were category 6. Thus, 18 of the 20 detected 60 and 81 mm mortars were in categories 4–6. Note from Table 2 that chance detection theory indicates that 10 of the 24 ORAGS detections of emplaced UXO in categories 4–6 were likely chance detections. Based on those numbers, about 40% of the 60 and 81 mm detections were likely by chance. In contrast, only six of the 22 ORAGS detections of 105 mm mortars and 2.75 inch rockets fell in categories 4–6.

Figures 12–14 provide location-error scatter plots for the three systems where the 1.5 m halo data have been used. The ORAGS locations are biased 23 cm north and 22 cm west, with error standard deviations of 81 cm and 56 cm in each direction. The aMTADS locations are biased 4 cm north and 4 cm west, with standard deviations of 31 cm and 32 cm. The gMTADS locations are biased 4 cm south and 1 cm east, with standard deviations of 13 cm and 12 cm.

Figures 15–17 provide similar data for radial location error, which is defined as the square root of the sum of the squares of the east and north errors. For the emplaced items, ORAGS demonstrated an average radial location error of 97 cm, and aMTADSE showed a 33 cm average radial error for those targets. In contrast, gMTADS average radial error was only 13 cm.

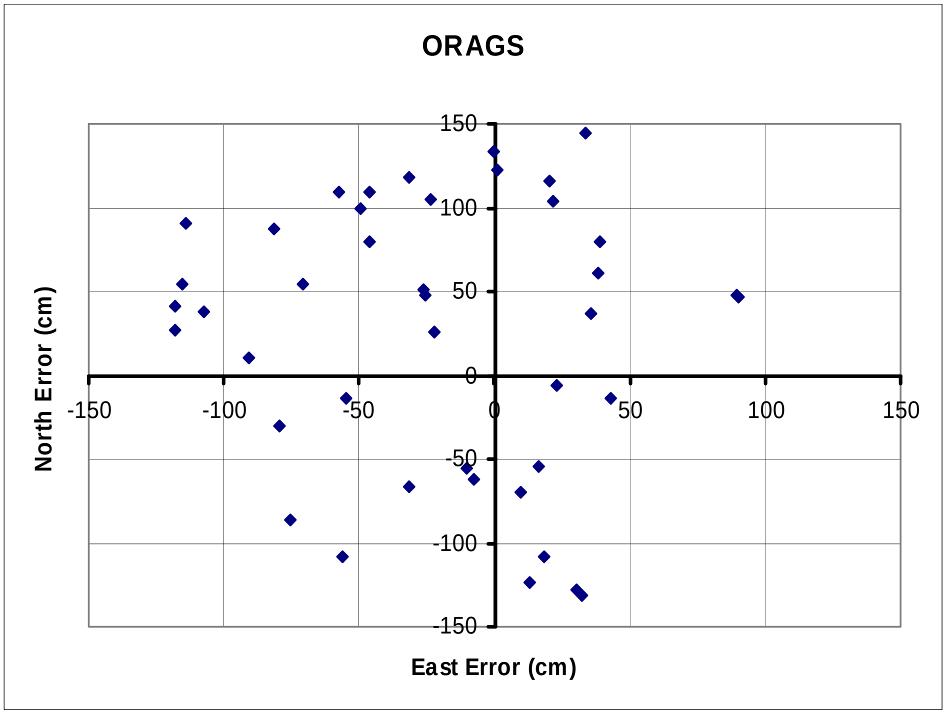


Figure 12. ORAGS Location Error Scatter Plot for Isleta Emplaced Items and a 1.5 m Halo

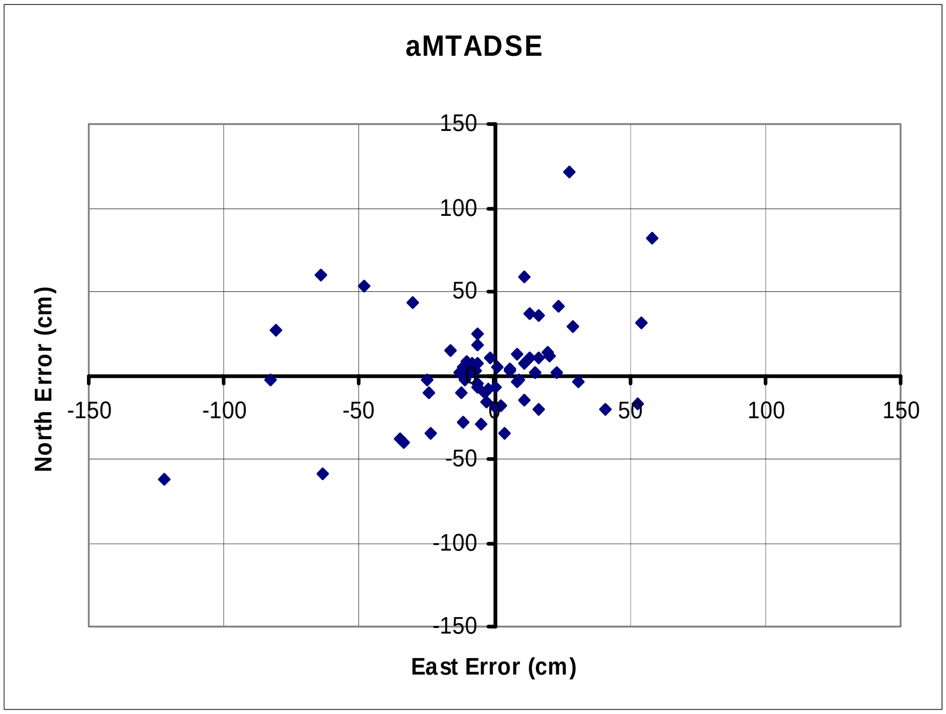


Figure 13. aMTADSE Location Error Scatter Plot for Isleta Emplaced Items and a 1.5 m Halo

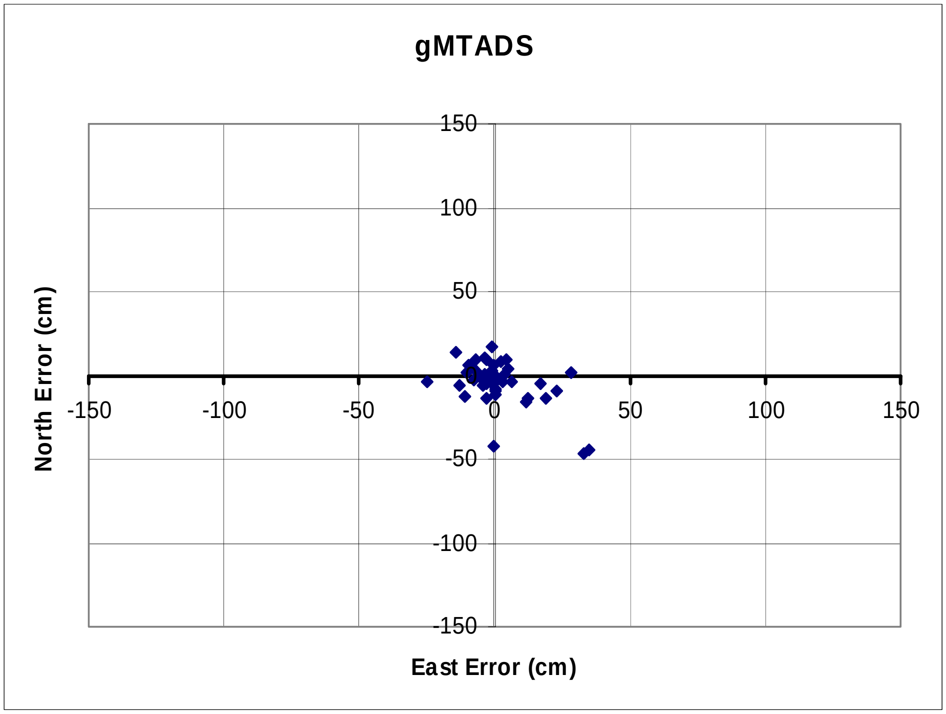


Figure 14. gMTADS Location Error Scatter Plot for Isleta Emplaced Items and a 1.5 m Halo

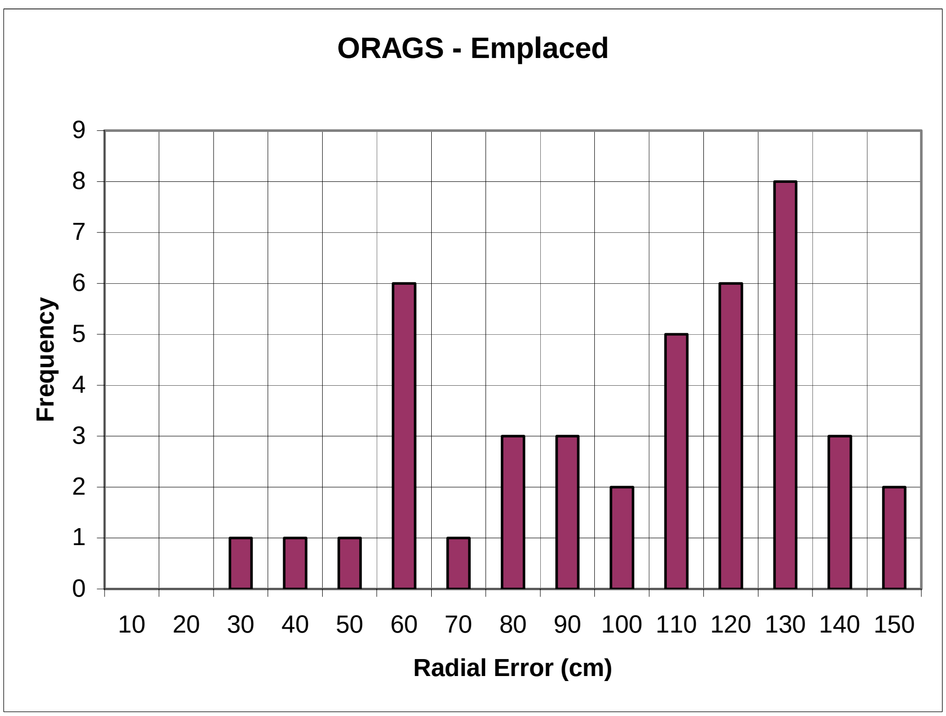


Figure 15. ORAGS Radial Location Error Histogram for Isleta Emplaced Items and a 1.5 m Halo

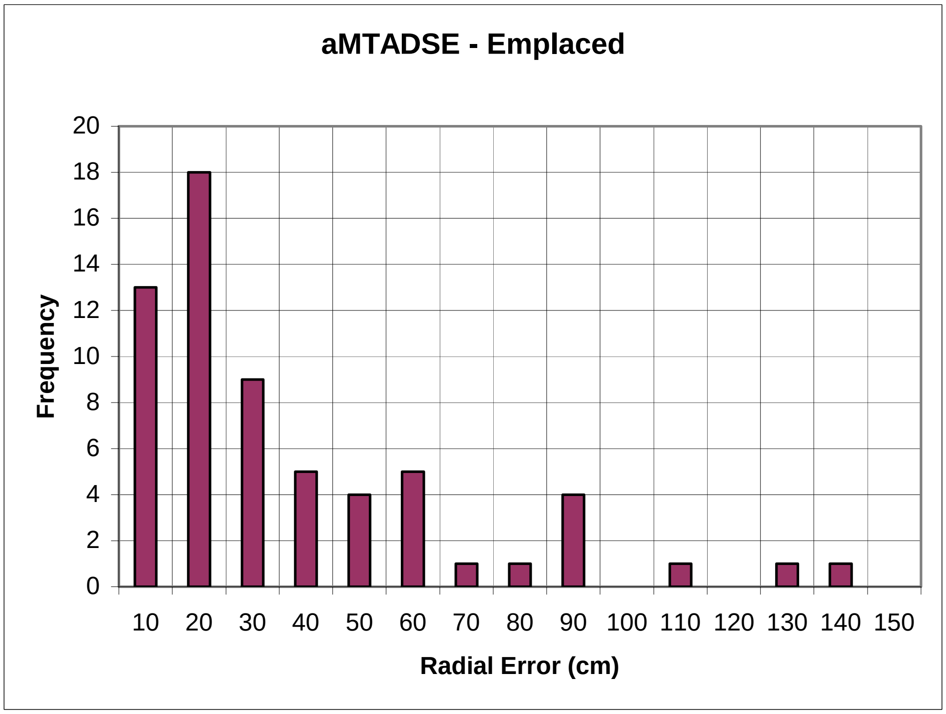


Figure 16. aMTADSE Radial Location Error Histogram for Isleta Emplaced Items and a 1.5 m Halo

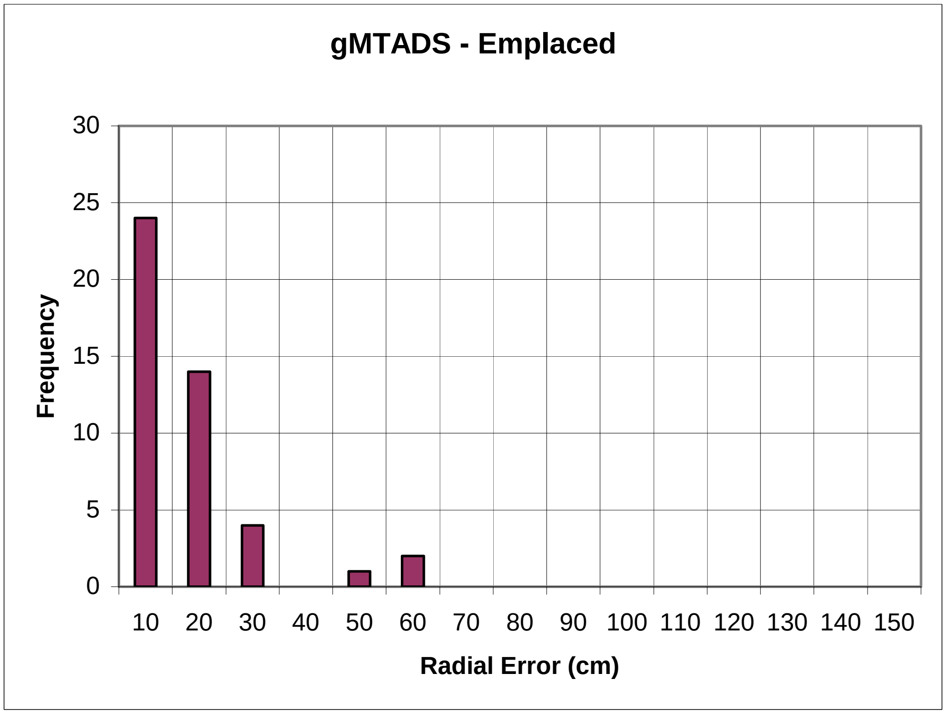


Figure 17. gMTADS Radial Location Error Histogram for Isleta Emplaced Items and a 1.5 m Halo

C. THREE-SYSTEM AREA PERFORMANCE

The second set of performance analyses was undertaken on the area that was jointly covered by all three systems. Based on the detection lists produced by each system, a joint dig list was formed. The gMTADS was effectively used as the reference to establish the dig list, which included all of the category 1 and 2 picks for gMTADS, plus some detections highlighted as very large items. Thus, Pd for the three-system area is the probability that a system detected dug items initially classified by the gMTADS as likely ordnance. Even for targets providing matches from all three systems, the dig list used gMTADS target locations because of the demonstrated superior geolocation performance of that sensor. In the test, 272 items were dug and sorted into 5 classes: intact ordnance, ordnance-related scrap, non-ordnance-related clutter, geology, and empty hole. A match was then performed against the three detection lists, using actual dug coordinates of the recovered items, not the coordinates provided to the dig team. The results: 260 of those items matched gMTADS category 1 or 2 items, 1 matched a gMTADS category 4 item, and 11 matched no gMTADS item. Five digs had no match to any of the three systems. In every case for the five unmatched items, there was a declaration within the halo of the dug item, but the declaration was closer to another dug item and was associated with it instead. These misses apparently resulted from cases where more than one object was detected by the dig team in the vicinity of a dig list coordinate, and more than one item was recovered and listed in the database. Because of the unmatched items, even gMTADS, the reference system for the dig, did not achieve a Pd of unity. Table 3 provides the number of items in each class, sorted by the gMTADS discrimination category into which it fell. Note that there were no empty holes in this case.

Table 3. Three-System Area Dug Items by Category and gMTADS UXO Likelihood Category

UXO Likelihood	Intact Ordnance	Ordnance-related scrap	Non-Ordnance-related clutter	Geology	Empty hole
1	54	159	7	1	0
2	6	27	4	2	0
4	0	1	0	0	0
No Match	5	5	0	1	0
Total	65	192	11	4	0

Two classes in Table 3 relate to ordnance. In scoring system performance, we have chosen to calculate Pd and background alarm rates two ways. First, we count only intact ordnance in Pd; ordnance-related scrap detections count in the false-alarms (case 1). Second, we group intact ordnance and ordnance-related scrap into Pd; non-ordnance-related clutter and geology detections contribute to the false-alarm rate (case 2). In both cases, the dug items are not included in the background alarm rate. Figure 18 provides both sets of calculations for the 1.5 m halo; Figure 19 provides data for a 2.0 m halo. The detections and background alarm rates are based on 6,676 declarations by ORAGS, 1,136 by aMTADSE, and 1,237 by gMTADS.

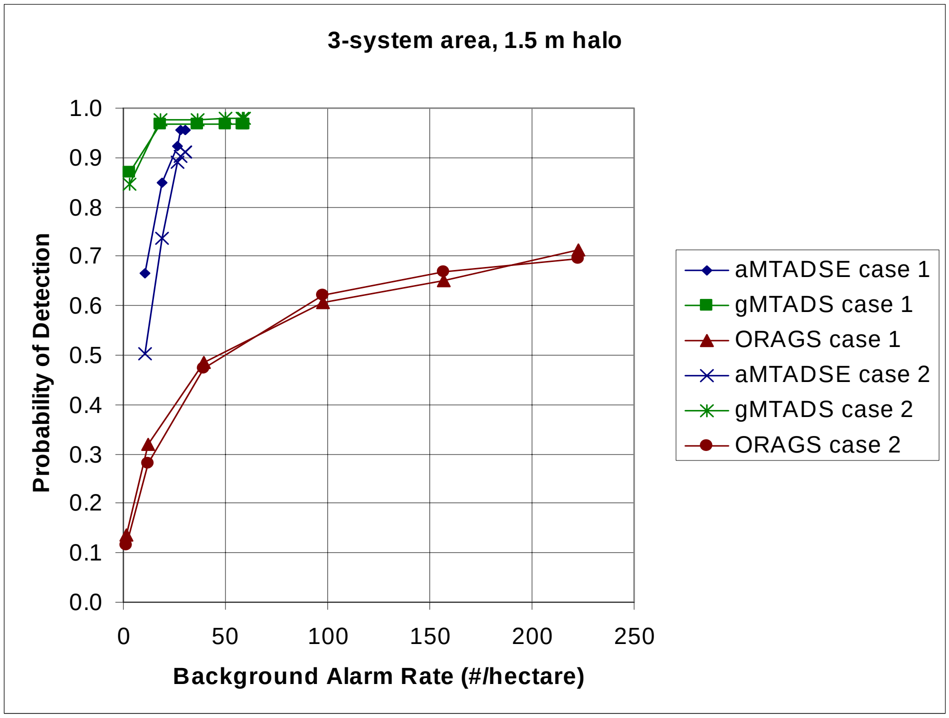


Figure 18. Pd vs. Background Alarm Rate for the Three-System Area and a 1.5 m Halo

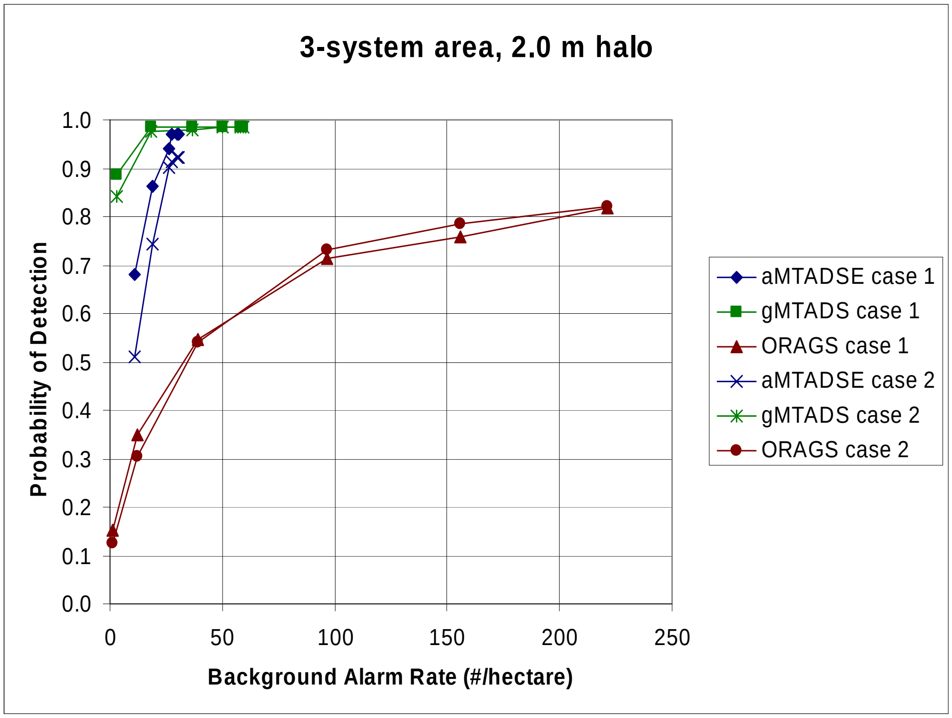
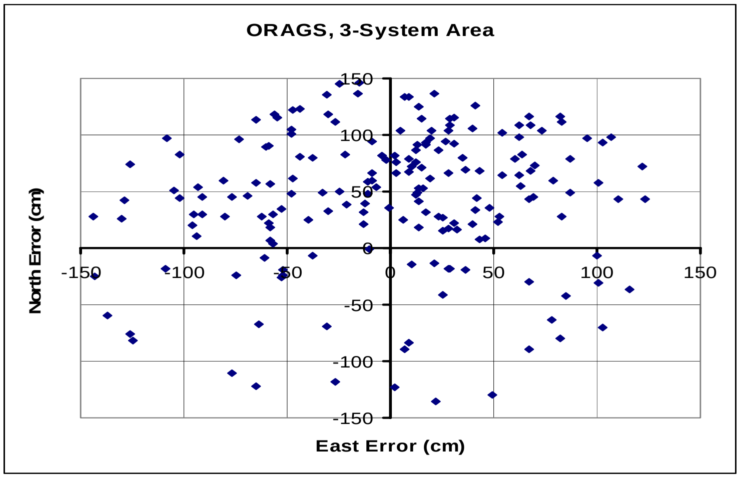


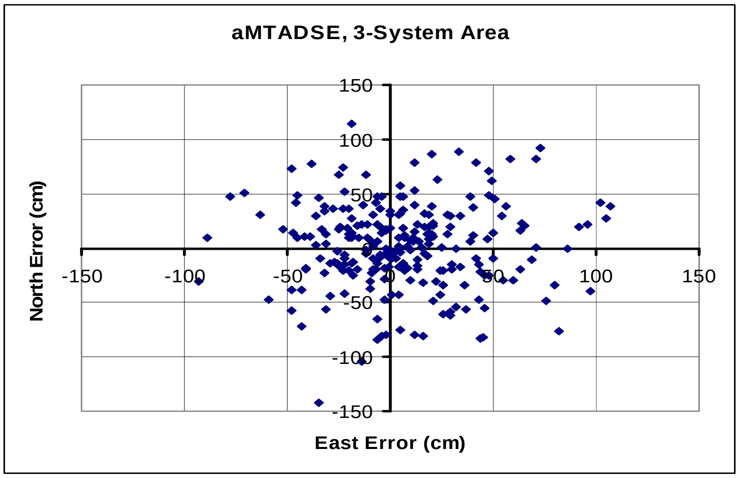
Figure 19. Pd vs. Background Alarm Rate for the Three-System Area and a 2.0 m Halo

We also completed an analysis of location-error statistics. Table 4 provides the mean location errors and standard deviations for each system. Figure 20 provides scatter plots of those data for the 1.5 m halo detections. We also found it of interest to investigate how the radial errors were distributed, and Figure 21 provides histograms of those data for the three systems, again for the 1.5 m halo.

Table 4. Location Error Statistics for the Three-System Area and 1.5 m Halo

	Mean Error (cm)		Error Std. Dev (cm)	
System	**North**	**East**	**North**	**East**
ORAGS	45	–1	60	61
aMTADSE	2	6	39	35
gMTADS	1	6	26	25





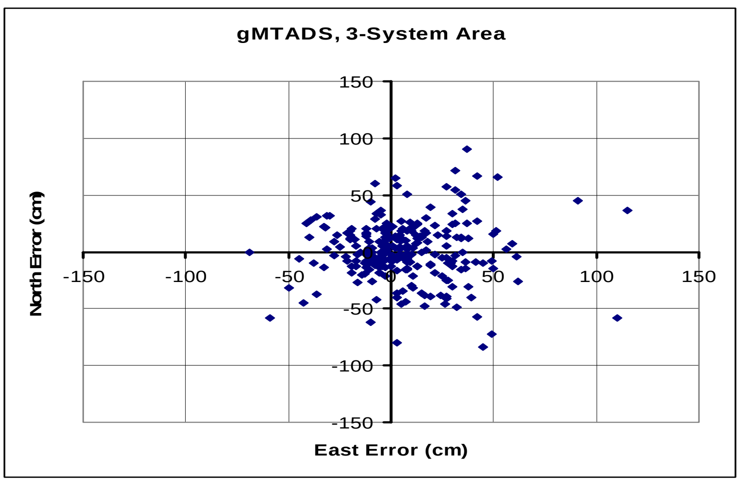
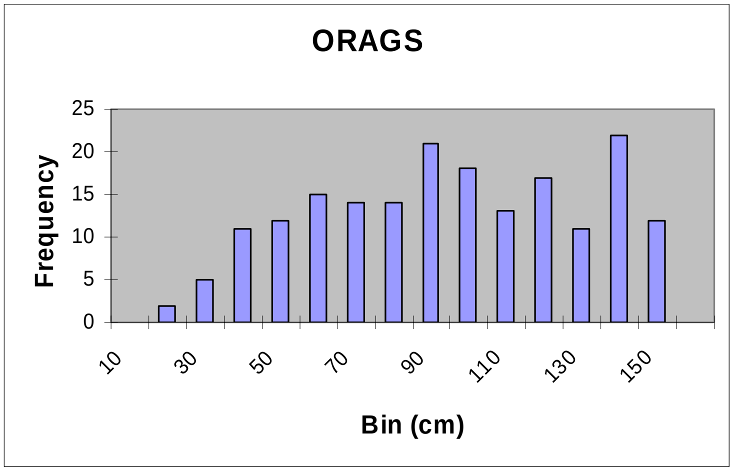
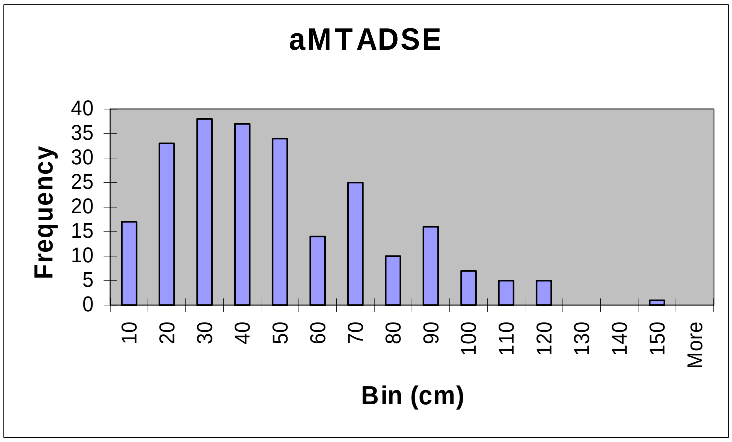


Figure 20. Scatter Plot of Location for the Three-System Area and 1.5 m Halo for ORAGS (top), aMTADSE (middle), and gMTADS (bottom)





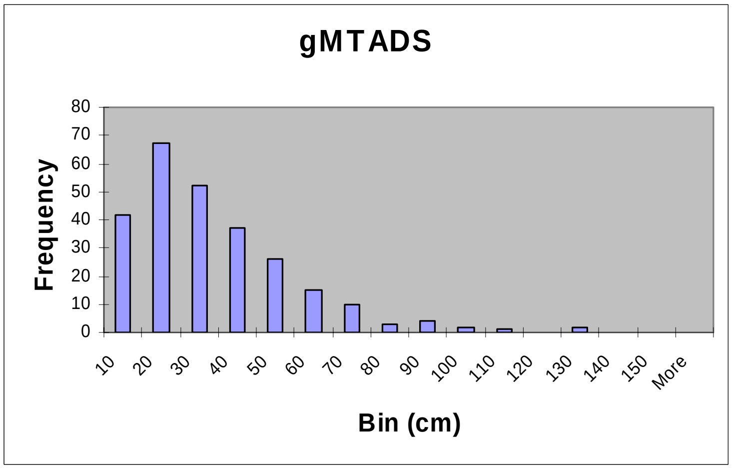


Figure 21. Radial Location Error Histograms for the Three-System Area and 1.5 m Halo for ORAGS (top), aMTADSE (middle), and gMTADS (bottom)

Finally, we used the three-system data to evaluate discrimination performance for all systems. Table 5 gives the airborne system results, cross-referenced for the gMTADS category 1 matches in the tables in Appendix C. Because the dig list concentrated on gMTADS category 1 and 2 items, we would have hoped that the dig results would be heavily biased toward intact UXO. Note from Table 3, however, that only 65 of the 272 recovered items were intact ordnance. On the other hand, for the items matched to gMTADS category 1 or 2 calls, only 14 of the 260 items were non-ordnance-related clutter (11) or geological (3) in nature. Thus, the gMTADS appeared to show an excellent capability for discriminating ordnance-related detections from non-ordnance-related ones, albeit with much less capacity to discriminate intact ordnance from ordnance-related scrap.

Table 5. Airborne System Discrimination Results from the Three-System Area Matches

System	Category	Intact Ord.	Ord. Frag.	Clutter	Geology
ORAGS	**1**	9	21	0	0
	2	12	30	0	0
	3	11	39	2	1
	4	7	31	1	0
	5	3	9	2	2
	6	4	3	0	0
	No Match	19	59	6	1
aMTADSE	**1**	44	85	4	1
	2	12	48	1	1
	3	5	35	1	0
	4	2	1	0	0
	5	0	2	0	0
	6	0	0	0	0
	No Match	2	21	5	2

The aMTADS uses the same discrimination algorithms as gMTADS, but they are applied against a much less dense set of magnetometer sample points with poorer signal-to-noise ratio because of increased target-to-sensor separation. aMTADS placed 56 of the 65 intact ordnance items in categories 1 or 2, with five items in category 3, two in category 4, and two not detected. Similarly, 133 of the 192 ordnance fragment items also appear in categories 1 and 2. Seven of the fifteen non-ordnance-related items were not detected by aMTADS, but seven of the eight detected items were ranked as category 1 or 2. In fact, 196 of the 242 items matched by aMTADS were in categories 1 and 2, and 41 more were in category 3, so the classification algorithm leaned heavily toward the more likely ordnance categories, as categories 4 and 5 had only five matches among them (three in category 4 and two in category 5), and category 6 had no matches.

ORAGS detection reports were more evenly weighted over the six categories, with 125 detections in categories 1–3 and 62 in categories 4–6. However, only 21 of the 46 detected intact ordnance items appeared in categories 1 or 2, and seven intact ordnance items fell in categories 5 and 6. Ordnance fragment detections were concentrated in categories 1–4, but with relatively somewhat fewer items in category 1, in contrast to aMTADS. The detected non-ordnance-related items were in categories 3, 4, and 5, so there was less tendency than in the aMTADS case to call non-ordnance items likely ordnance related.

D. PRIMARY (AIRBORNE-ONLY) AREA

The third set of data analyzed was from the area covered only by the two airborne systems. A dig list was generated from the high-priority (category 1 and 2) items for each system. As noted before, for items that appeared within a halo of each other for the two lists, aMTADS coordinates were used in the dig list because of the smaller location errors that system demonstrated against the emplaced targets. Obviously, for items without an apparent match on the other list, the dig list used the coordinates provided by the detecting system. As in the three-system area, post-dig matches were done on the dug coordinates, not the dig list coordinates. Nevertheless, it is possible that preferential use of aMTADS coordinates resulted in some residual bias in the results, although the resulting ROC curves and location-error plots are consistent with those based on the emplaced items and three-system area.

A total of 161 items were dug. ORAGS made 10,876 declarations in the area scored, and aMTADS made 366 declarations. Of those, 215 of the ORAGS declarations were in categories 1 and 2, and 164 of the aMTADS calls fell in the first two categories.

The ORAGS list contained matches for 131 of the dug items, of which 94 appeared in categories 1 and 2. For aMTADS, 111 of the matching 126 items were in categories 1 and 2. Because there was no real reference system, unlike in the three-system area, we have chosen to label ROC curves ordinates “fraction of dug items matched,” vice Pd. Figure 22 provides a map of the airborne-only area with the dug items and UXO likelihood category 1 and 2 declarations from each system indicated.

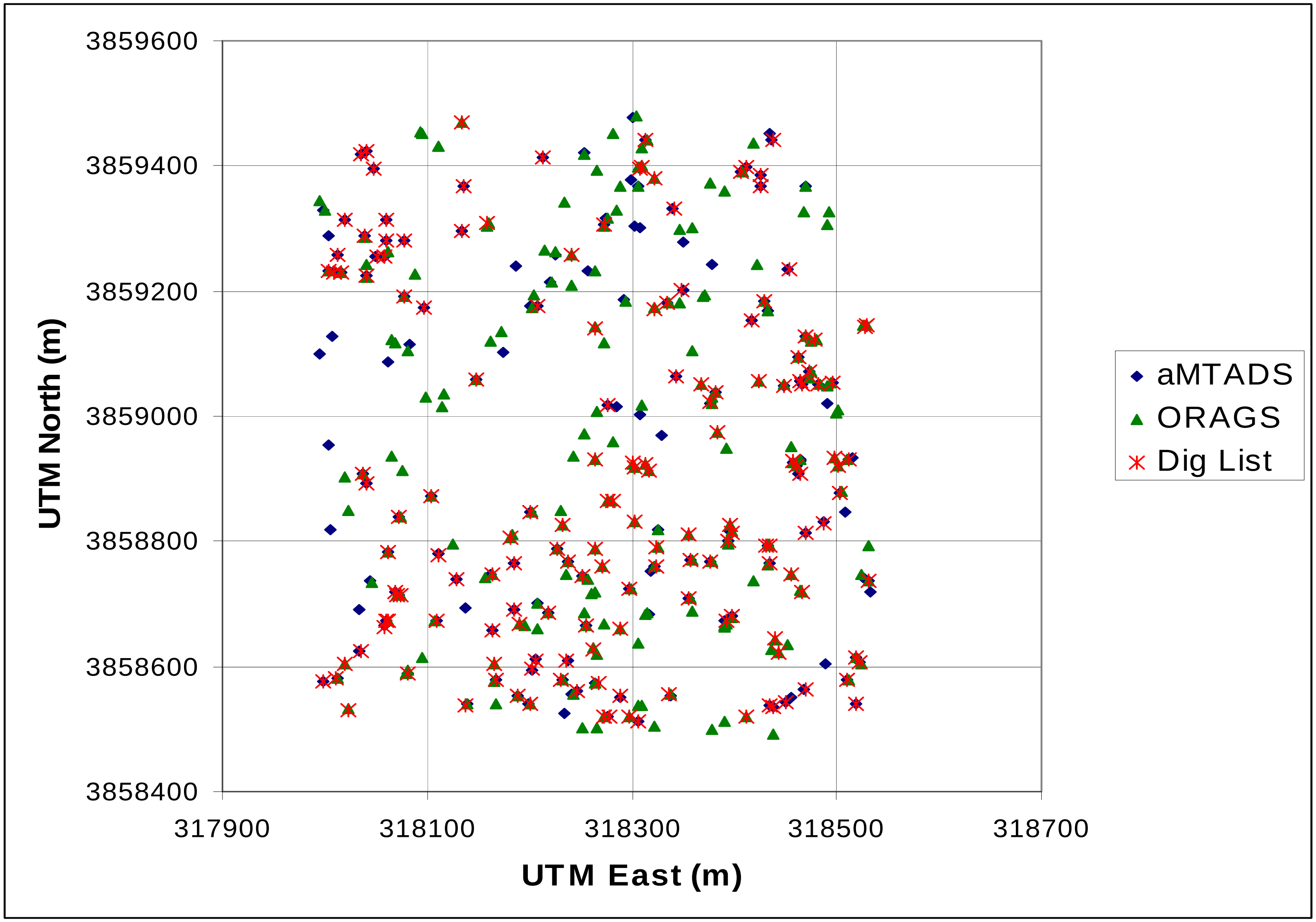


Figure 22. Airborne-Only Area with Dug Items and Category 1 and 2 Declarations from Each System

Figures 23 and 24 provide ROC curves for 1.5 m and 2.0 m radius halos. Scoring, as for the three-system area, was done twice, once with only intact ordnance contributing to detection (case 1) and once with ordnance scrap also contributing (case 2). Note that we have shifted to a logarithmic scale for background alarm rate to better display the data.

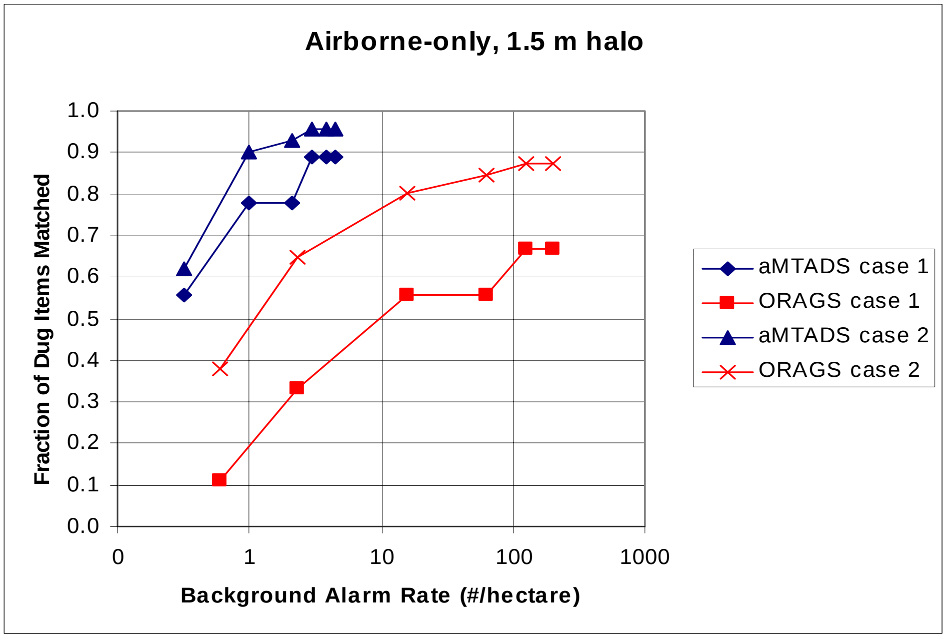


Figure 23. Airborne-Only Area ROC Curves for a 1.5 m Halo

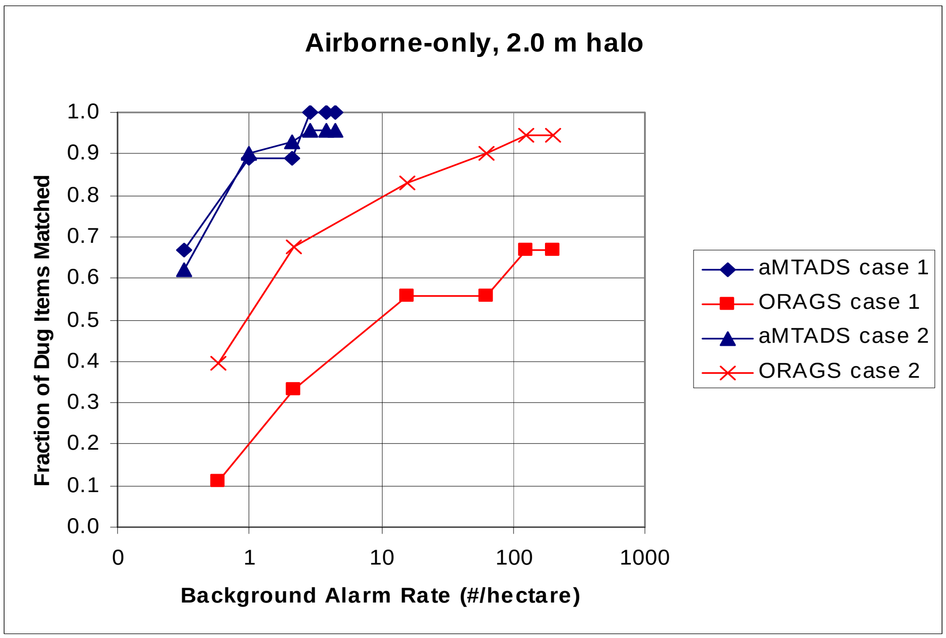
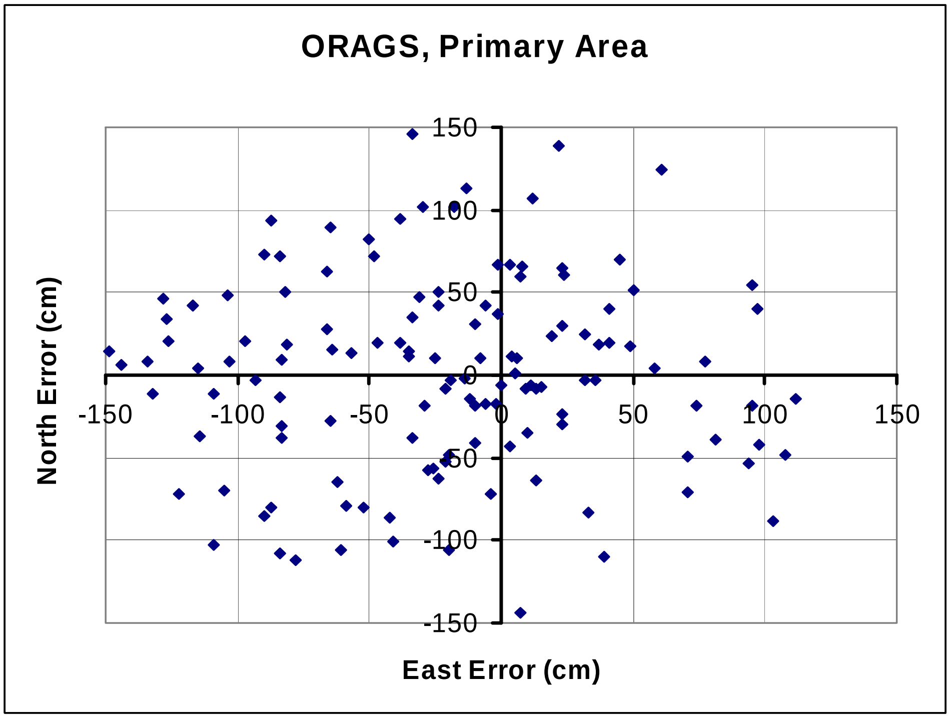


Figure 24. Airborne-Only Area ROC Curves for a 2.0 m Halo

Figure 25 provides location error scatter plots based on the 1.5 m halo data. Figure 26 provides the associated radial error histograms, and Table 6 provides the error statistics.



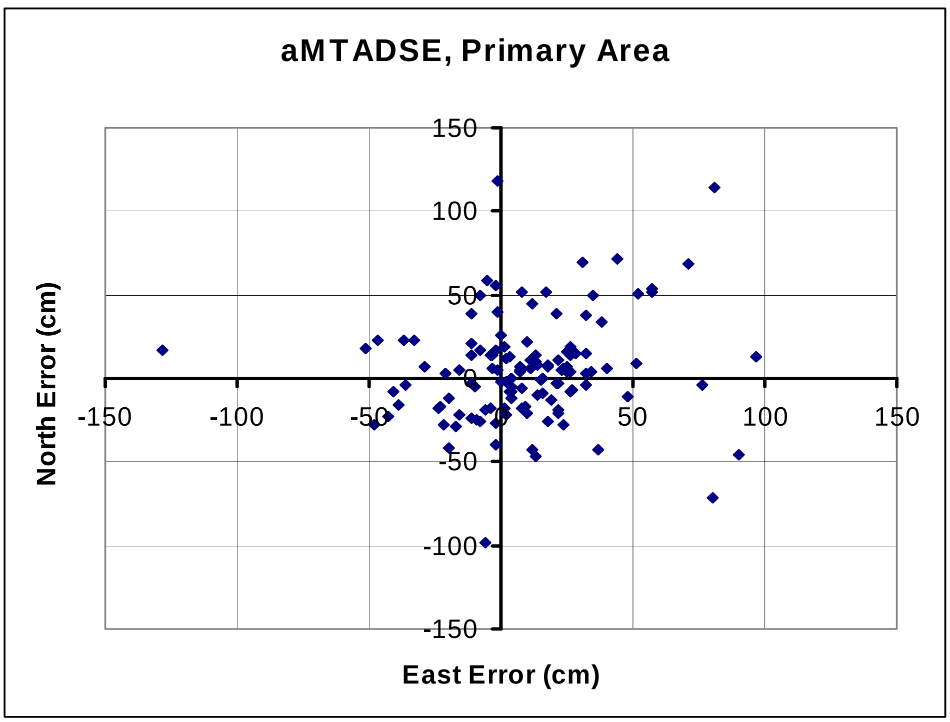
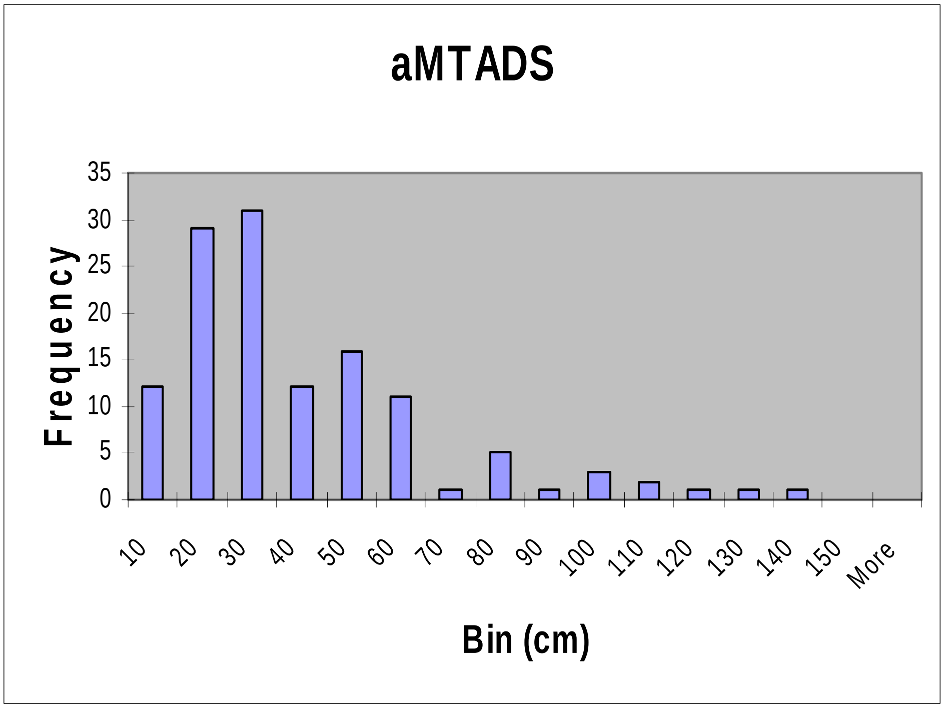


Figure 25. Location-Error Scatter Plots for the Airborne-Only Area, Based on a 1.5 m Halo



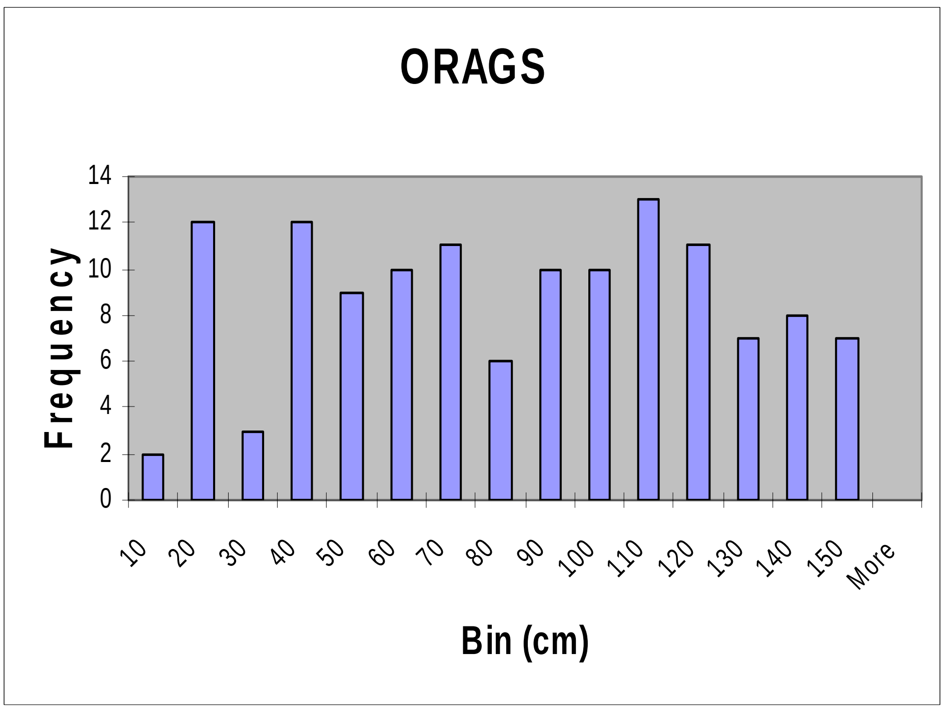


Figure 26. Radial Location Error Histogram for the Airborne-Only Area, Based on a 1.5 m Halo for ORAGS (top) and MTADS (bottom)

Table 6. Location Error Statistics for the Airborne-Only Area and 1.5 m Halo

System	Mean Error (cm)		Error Std. Dev (cm)	
	North	East	North	East
ORAGS	1	–22	58	62
aMTADSE	5	9	31	30

III. FINDINGS AND CONCLUSIONS

A. FINDINGS

This was the second in a pair of demonstrations designed to test the detection and classification capabilities of airborne magnetometer systems over a wide range of terrain types and levels of background clutter. At Isleta, 112 UXO were emplaced in an area containing substantial ferrous clutter to provide known items against which system performance could be judged. This report focuses on the detection and discrimination performance of the two helicopter systems, although it is also enlightening to compare that performance to the ground-based system.

These two systems employ similar cesium vapor magnetometers carried on identical helicopters, so we would expect their inherent signal sensitivities to be similar, and that was the case for the calibration targets and airfield targets analyzed in the earlier Aberdeen Proving Ground report [5]. However, as in the earlier case, the aMTADS flew at lower altitudes than did the ORAGS. Based on an IDA analysis of altitude data provided by NRL and ORNL, aMTADS flew Isleta at an average altitude of 1.4 m with a 0.5 m standard deviation, and ORAGS flew at an average altitude of 3.0 m with a 1.5 m standard deviation. Jeff Gamey of ORNL, in a personal communication [6], stated that ORAGS typically flew at altitudes between 1.5 and 2.5 m over the areas where most of the scoring was done. In a situation where signal strength is expected to fall off as $1/(\text{distance})^3$, a 26% difference in altitude results in a factor of 2 difference in signal strength, and going from 1.4 m to 2.5 m reduces signal strength by more than a factor of 5. Thus, as at APG, aMTADS's lower altitude gave it a signal strength advantage that certainly contributed to its better detection performance.

While the difference between ORAGS and aMTADS performance was significant, both suffered in comparison to the vehicle-towed system. The gMTADS 25 cm sensor height should give it much better detection performance than the helicopter sensors, and that proved to be the case at Isleta. gMTADS detected every one of the emplaced ordnance items over which its sensor array traveled. In evaluating the two missed items within the gMTADS survey area, it was apparent from recorded vehicle track data that the items fell in coverage gaps that were recognized and would have been resurveyed, had not the system broken down. In contrast, the airborne systems did not fare that well in the cluttered Isleta environment, even against the larger emplaced UXO. aMTADS detected only 19 of 40 81 mm mortars and 29 of 40 105 mm shells, while ORAGS did even more poorly, detecting 15 each of the 81 mm and 105 mm emplaced targets. Neither helicopter-based sensor system was initially designed to detect targets as small as 60 mm mortar shells, and the Isleta testing confirmed that neither system fares well against such targets in a cluttered environment.

B. CONCLUSIONS

Several conclusions can be drawn from the results of these demonstrations:

- Both systems, with their current, associated, data-processing techniques, are capable of reliably detecting areas of high clutter and potential UXO density.
- If maximum sensitivity is desired, it is important that an airborne system design allow very low-level flight in areas where that is possible.
- While the ground-based system detected every emplaced ordnance item within its actual survey area, neither helicopter-based system demonstrated reliable detection of small ordnance (25% probability of detection or less against 60 mm mortar rounds). In addition, aMTADS detected only three-fourths of the 105 mm rounds and ORAGS detected less than one-third of those rounds. Those detection statistics would argue against the use of the helicopter systems for individual UXO detection, except for large ordnance in benign topography, land cover, and magnetic background situations.
- aMTADS's consistent ability to more accurately determine target position (33 cm average radial error on the emplaced targets vs. 97 cm for ORAGS) improves target reacquisition performance and reduces ambiguity opportunities.
- Current automated target detection and recognition algorithms do not appear to be robust or accurate enough to replace the use of human judgment in interpreting the magnetometer data and determining which targets are likely UXO.

ACRONYMS

aMTADS	Airborne Multi-Sensor Towed Array Detection System
aMTADSE	Airborne Multi-Sensor Towed Array Detection System-Extended Data Set
ERDC	Engineering R&D Center
ESTCP	Environmental Security Technology Certification Program
gMTADS	Vehicle Towed Multi-Sensor Towed Array Detection System
GPS	Global Positioning System
IDA	Institute for Defense Analyses
MTADS	Multi-Sensor Towed Array Detection System
NRL	Naval Research Laboratory
ORAGS	Oak Ridge Airborne Geophysics System
ORNL	Oak Ridge National Laboratory
Pd	probability of detection
ROC	receiver operating characteristics
SERDP	Strategic Environmental Research and Development Program
UXO	unexploded ordnance

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2. "Final Report on 2003 Airborne Geophysical Survey at Pueblo of Isleta Bombing Targets, New Mexico," prepared by the Environmental Sciences Division, Oak Ridge National Laboratory, under ESTCP Project 200037, October 2004.
3. Andrews, A., V. George, T. Altshuler, and M. Mulqueen, "Results of the Countermine Task Force Mine Detection Technology Demonstration at Fort A.P. Hill, VA, March 18–22, 1996," IDA paper P-3192, July 1996.
4. Papoulis, A., *Probability, Random Variables and Stochastic Processes*, McGraw-Hill, 1965, p. 195.
5. Tuley, M, E. Dieguez, and J. Biddle, "Analysis of Airborne Magnetometer Data from Tests at Aberdeen Proving Ground, Maryland, June 2002," IDA document D-3015, July 2004.
6. Gamey, T. Jeffrey, e-mail message to E. Dieguez dated 7/20/2004 and titled "Re: ORNL Altimeter data."

APPENDIX A
CHANCE DETECTION ANALYSIS

Evaluators long ago realized that in analyzing detection performance, some number of detections were likely to be due to chance. That is, a certain number of detections that are graded as true detections are not actually associated with the item assumed to be detected. To illustrate the point, if N detection calls were randomly distributed over a test plot with area A, a demonstrator might expect, just based on chance, to achieve an apparent probability of detection approximately equal to $N\pi R_h^2/A$, where R_h is the radius of the halo used. A more sophisticated analysis is developed in Reference 3 to assess the number of "chance" detections. The assumption made is that the survey instrument has inherent random errors in locating targets that can be described by zero-mean and equal variance Gaussian distributions in the east and north directions. For that assumption, we would expect that the probability density function for the radial error would be Rayleigh and the probability of detecting an object within a radius R_h of the declared location would be given by [4]:

$$P(z \leq R_h) = \int_0^{R_h} \frac{z}{\sigma^2} e^{-z^2/2\sigma^2} = 1 - e^{\frac{-1}{\sqrt{2}}\left(\frac{R_h}{\sigma}\right)^2} ,$$

where σ is the location error standard deviation in the east and north directions. If the halo is substantially larger than the error standard deviation, then the probability that a detected target lies inside the halo is essentially unity. For example, for an $R_h/\sigma = 2$, the probability is 94%, and for $R_h/\sigma = 2.5$ it is 99%. From the Isleta emplaced object detections, the average of the east and north error standard deviations was 69 cm for ORAGS and 32 cm for aMTADS. The 1.5 m standard halo used in the Isleta analysis is just more than twice the ORAGS average standard deviation, and so approximating the probability as unity, while not as accurate as might be desirable, is still reasonable. In many cases, however, we have also provided results for a 2.0 m halo to illustrate the detection difference that value provides for the ORAGS. Applying the approximation that the probability distribution function equals unity to the analysis gives the number of "true" detections as

$$T = M - U \cdot F \cdot \alpha$$

where

T = number of true matches

U = true number of missed detections = $B – T$

B = number of items buried

F = true number of false detections = $D – T$

D = number of target declarations

α = (area of halo)/(area of site)

M = Sum of true + lucky matches

This results in a quadratic in T whose solution is

$$T = \frac{-\left(\frac{1}{\alpha} - B - D\right) + \sqrt{\left(\frac{1}{\alpha} - B - D\right)^2 - 4\left(BD - \frac{1}{\alpha}M\right)}}{2}.$$

Curves of true detections as a function of halo should increase as halo size increases and reach an asymptotic value that is indicative of sensor detection performance. For a sensor that produces small position estimation errors, the curve rises rapidly to its final value, but for a sensor with less accurate positioning, the curve asymptotes more slowly. When actual data are plotted, however, curves of true detections reach a peak value and eventually start to decrease with increasing halo. The apparent decrease is due to a violation of the assumptions under which the above equations were derived. The analysis assumes that declarations are widely enough separated so that halos never overlap and that portions of halos never lie outside the analysis area. At some point, those assumptions break down and the number of chance detections does not continue to rise proportionally to the halo area, so more chance detections are calculated than actually occur. However, until the assumptions are violated, the above development gives a good estimate of true versus chance detections.

APPENDIX B
THREE-SYSTEM AREA DIG RESULTS

This section provides the results of the recovery operation based on gMTADS category 1 and 2 calls in the area covered by all three systems. The coordinates provided to the dig team were based on gMTADS positions; however, the coordinates in the table are the actual locations of the items as they were recovered. IDA sorted the items into five categories for scoring: intact ordnance, ordnance fragments, non-ordnance-related clutter, geology, and empty. The match list is based on a 1.5 m halo around the recovered item, and the miss distance for each system is provided.

Table B-1. Three-System Area Dig Results

Ground-Truth				gMTADS					aMTADSE					ORAGS				
ID	DESCRIPTION	UTMNORTH	UTMEAST	ID	UTMNORTH	UTMEAST	Call	Miss (m)	ID	UTMNORTH	UTMEAST	Call	Miss (m)	ID	UTMNORTH	UTMEAST	Call	Miss (m)
AS1-1	MK-76 Practice Bomb	3857181.50	318510.23	17	3857181.40	318510.16	1	0.12	612	3857181.31	318510.04	1	0.27					
AS1-2	MK-76 Practice Bomb	3857178.03	318532.68	18	3857177.87	318532.18	1	0.53	610	3857177.74	318532.14	1	0.61					
AS1-3	M38 Bomb Body Fragments	3857172.90	318577.46															
AS1-4	MK-76 Practice Bomb	3857174.27	318674.28	31	3857174.63	318674.13	1	0.39	21	3857174.92	318674.34	2	0.65					
AS1-5	M38 Bomb Body Fragments	3857166.30	318691.35	34	3857166.87	318690.93	1	0.71	25	3857167.34	318691.49	4	1.05					
AS1-6	M38 Bomb Body Fragments	3857185.84	318715.57	41	3857185.47	318715.22	1	0.51	31	3857185.36	318715.09	1	0.68	8679	3857184.5	318715.5	6	1.34
AS1-8	M38 Bomb Body Fragments	3857192.14	318728.54	50	3857192.53	318728.27	1	0.47	33	3857192.89	318728.49	1	0.75	16	3857191.5	318728.0	1	0.84
AS1-9	M38 Bomb Body Fragments	3857197.13	318660.43	63	3857197.13	318661.12	1	0.69	24	3857197.03	318661.32	3	0.90					
AS1-10	M38 Bomb Body Fragments	3857193.70	318666.17	64	3857194.28	318665.07	1	1.24	23	3857194.46	318665.35	1	1.12	51	3857194.0	318665.5	1	0.73
AS1-11	M38 Bomb Body Fragments	3857203.21	318604.65	68	3857203.03	318604.60	1	0.19	17	3857203.14	318604.55	1	0.12	5286	3857202.5	318604.5	4	0.73
AS1-12	M38 Bomb Body Fragments	3857223.81	318499.19	78	3857223.89	318499.36	1	0.19	616	3857223.89	318499.20	2	0.08	5108	3857224.5	318499.5	4	0.76
AS1-13	M38 Bomb Body Fragments	3857233.18	318531.92	85	3857232.96	318532.25	1	0.40	619	3857233.01	318532.44	1	0.55	4861	3857233.0	318532.5	4	0.61
AS1-14	MK-76 Practice Bomb	3857212.68	318628.79	96	3857212.23	318628.43	1	0.58	42	3857211.86	318628.21	2	1.00					
AS1-15	Magnetic Rock	3857224.24	318639.74	98	3857224.12	318639.75	1	0.12						8094	3857225.0	318641.0	5	1.47
AS1-16	M38 Bomb Body Fragments	3857221.95	318696.09	107	3857221.75	318696.28	1	0.28	41	3857221.82	318695.91	1	0.22	106	3857221.5	318697.0	1	1.02
AS1-17	M38 Bomb Body Fragments	3857211.47	318729.12	116	3857211.52	318729.20	1	0.09	39	3857211.48	318729.14	1	0.02	185	3857211.0	318729.0	2	0.49
AS1-18	M38 Bomb Body Fragments	3857239.87	318698.84	126	3857239.72	318699.10	1	0.30	57	3857239.45	318698.91	3	0.43	2794	3857238.5	318699.0	3	1.38
AS1-19	M38 Bomb Body Fragments	3857246.04	318674.57	134	3857246.14	318674.70	1	0.16	54	3857245.95	318674.76	1	0.21	1138	3857245.5	318675.5	3	1.08
AS1-20	M38 Bomb Body Fragments	3857259.78	318662.87	140	3857259.87	318662.91	1	0.10	53	3857259.57	318663.03	1	0.26					
AS1-21	MK-76 Practice Bomb	3857245.07	318583.92	153	3857244.90	318583.95	1	0.17	45	3857244.93	318583.96	1	0.15	2700	3857245.0	318584.5	3	0.58
AS1-22	M38 Bomb Body Fragments	3857250.30	318554.85	157	3857250.17	318554.88	1	0.13	620	3857250.14	318554.87	1	0.16	116	3857249.5	318554.5	1	0.87
AS1-23	M38 Bomb Body Fragments	3857269.21	318500.90	166	3857269.37	318500.56	1	0.38	631	3857269.22	318500.58	1	0.32	300	3857269.0	318500.5	2	0.45
AS1-24	MK-76 Practice Bomb	3857287.87	318526.44	183	3857287.67	318526.48	1	0.20	639	3857287.30	318526.39	1	0.57					
AS1-25	M38 Bomb Body Fragments	3857262.60	318540.91	187	3857262.69	318540.97	1	0.11	622	3857262.78	318540.94	1	0.18	932	3857262.0	318541.0	2	0.61
AS1-26	MK-76 Practice Bomb	3857270.26	318573.25	189	3857269.97	318573.33	1	0.30	78	3857269.79	318573.29	1	0.47	1608	3857270.5	318574.0	3	0.79
AS1-27	AN/M57 500# Bomb	3857266.08	318620.35	195	3857265.85	318620.14	1	0.31	75	3857265.97	318620.14	1	0.24	1105	3857266.5	318619.5	3	0.95
AS1-28	AN/M57 500# Bomb	3857277.06	318630.90	196	3857276.72	318630.60	1	0.45	74	3857276.75	318630.62	1	0.42					
AS1-29	M38 Bomb Body Fragments	3857276.50	318644.30	199	3857276.35	318644.26	1	0.16	71	3857276.32	318644.24	1	0.19					
AS1-30	Tin Can	3857282.27	318739.02	219	3857282.32	318739.02	1	0.05						5617	3857283.5	318739.0	4	1.23
AS1-31	M38 Bomb Body Fragments	3857293.97	318710.95	232	3857294.05	318711.07	1	0.14	64	3857294.01	318710.90	1	0.06	130	3857293.0	318710.0	1	1.36
AS1-32	M38 Bomb Body Fragments	3857302.68	318697.68	236	3857302.70	318697.58	1	0.10	65	3857302.88	318697.75	1	0.21	117	3857302.0	318697.0	1	0.96
AS1-33	M38 Bomb Body Fragments	3857303.61	318688.06	240	3857303.40	318687.96	1	0.23	66	3857303.65	318688.04	1	0.04	112	3857303.5	318689.0	1	0.95
AS1-34	M38 Bomb Body Fragments	3857309.53	318698.40	241	3857309.32	318698.30	1	0.23	91	3857308.90	318698.17	2	0.67					
AS1-35	M38 Bomb Body Fragments	3857310.54	318682.20	242	3857310.42	318682.07	1	0.18	88	3857310.24	318681.86	2	0.45					
AS1-36	MK-76 Practice Bomb	3857300.75	318555.07	257	3857300.49	318554.98	1	0.28	641	3857300.57	318555.07	1	0.18	4487	3857301.0	318556.5	4	1.45
AS1-37	MK-76 Practice Bomb	3857287.58	318517.01	266	3857286.87	318516.70	1	0.77	636	3857286.81	318517.39	1	0.86	107	3857287.0	318516.0	1	1.16
AS1-38	MK-76 Practice Bomb	3857317.02	318522.66	274	3857316.88	318522.64	1	0.14	650	3857317.16	318522.60	1	0.15					
AS1-39	M38 Bomb Body Fragments	3857326.86	318552.10	276	3857326.77	318552.38	1	0.29	648	3857326.91	318552.22	2	0.13	8435	3857327.0	318552.0	5	0.17
AS1-40	Tin Can Fragments	3857328.66	318674.59	285	3857328.70	318674.53	1	0.07						7825	3857329.5	318674.5	5	0.84
AS1-41	M38 Bomb Body Fragments	3857318.07	318712.44	296	3857318.23	318712.36	1	0.18	95	3857318.36	318712.34	1	0.31					
AS1-42	M38 Bomb Body Fragments	3857315.29	318736.37	306	3857315.34	318736.10	1	0.27	99	3857315.45	318736.24	1	0.21	786	3857314.5	318735.5	2	1.18
AS1-43	Tin Can	3857329.61	318749.69	316	3857329.75	318749.75	1	0.15										
AS1-44	MK-76 Practice Bomb	3857350.22	318562.60	328	3857350.17	318562.64	1	0.06	646	3857350.20	318562.52	1	0.08	2691	3857349.5	318562.5	3	0.73
AS1-45	M38 Bomb Body Fragments	3857358.38	318562.32	332	3857358.22	318562.34	1	0.16	660	3857358.47	318562.29	1	0.09					
AS1-46	MK-76 Practice Bomb	3857366.49	318595.87	340	3857366.24	318595.50	1	0.45	120	3857366.43	318595.48	1	0.39	796	3857366.0	318595.0	2	1.00
AS1-47	Wire	3857364.06	318599.14	341	3857364.04	318598.58	1	0.56										
AS1-48	MK-76 Practice Bomb	3857346.24	318636.19	347	3857346.26	318636.23	1	0.04	116	3857346.14	318636.30	1	0.15					

Ground-Truth				gMTADS					aMTADSE					ORAGS				
ID	DESCRIPTION	UTMNORTH	UTMEAST	ID	UTMNORTH	UTMEAST	Call	Miss (m)	ID	UTMNORTH	UTMEAST	Call	Miss (m)	ID	UTMNORTH	UTMEAST	Call	Miss (m)
AS1-49	Oil Filter	3857346.41	318704.14	369	3857346.38	318704.25	1	0.11						7159	3857346.0	318704.0	5	0.43
AS1-50	M38 Bomb Body Fragments	3857353.38	318713.39	372	3857353.29	318713.45	1	0.11	109	3857353.51	318713.57	2	0.22					
AS1-51	Pipe	3857356.76	318709.64	373	3857357.48	318709.15	1	0.87	110	3857357.59	318709.20	1	0.94					
AS1-52	MK-76 Practice Bomb	3857347.99	318713.63	375	3857347.97	318713.55	1	0.08	107	3857347.92	318713.73	1	0.12	710	3857347.5	318713.5	2	0.51
AS1-53	Tin Cans	3857341.15	318745.95	388	3857341.46	318745.57	1	0.49	104	3857341.36	318745.71	1	0.32					
AS1-55	M38 Bomb Body Fragments	3857383.54	318732.05	392	3857383.51	318732.08	1	0.04						9990	3857382.5	318732.0	6	1.04
AS1-56	M38 Bomb Body Fragments	3857365.52	318727.54	397	3857365.72	318727.68	1	0.24	108	3857364.84	318727.66	3	0.69	2290	3857364.5	318727.0	3	1.15
AS1-57	M38 Bomb Body Fragments	3857375.64	318723.72	398	3857375.71	318723.69	1	0.08	161	3857376.20	318724.03	2	0.64	5152	3857377.0	318723.5	4	1.38
AS1-58	M38 Bomb Body Fragments	3857376.38	318726.79	399	3857376.35	318726.88	1	0.09						861	3857376.0	318727.0	2	0.43
AS1-59	M38 Bomb Body Fragments	3857384.66	318724.17	405	3857384.56	318724.20	1	0.10	160	3857384.71	318724.00	1	0.18	4956	3857383.5	318723.5	4	1.34
AS1-60	M38 Bomb Body Fragments	3857374.78	318657.98	438	3857374.90	318657.79	1	0.22	1046	3857375.59	318658.02	5	0.81	2229	3857374.0	318658.0	3	0.78
AS1-61	M38 Bomb Body Fragments	3857373.34	318668.41	439	3857373.55	318668.16	1	0.33	147	3857373.68	318668.05	3	0.50	627	3857373.0	318668.0	2	0.53
AS1-62	M38 Bomb Body Fragments	3857380.65	318642.81	445	3857380.55	318642.77	1	0.11	139	3857380.57	318642.62	1	0.21	2783	3857379.5	318642.5	3	1.19
AS1-63	M38 Bomb Body Fragments	3857379.28	318638.33	446	3857379.21	318638.21	1	0.14	138	3857378.88	318638.21	2	0.42	2818	3857379.0	318637.5	3	0.88
AS1-64	M38 Bomb Body Fragments	3857384.47	318627.42	450	3857384.55	318627.46	1	0.09	137	3857384.65	318627.83	1	0.45	9306	3857383.5	318628.5	6	1.45
AS1-65	MK-76 Practice Bomb	3857386.37	318605.62	462	3857386.69	318605.51	1	0.34	127	3857386.98	318605.36	1	0.66	808	3857385.5	318605.5	2	0.88
AS1-66	MK-76 Practice Bomb	3857391.39	318574.23	467	3857391.42	318574.22	1	0.03	1258	3857391.67	318574.26	3	0.28	8599	3857392.5	318575.0	6	1.35
AS1-67	M38 Bomb Body Fragments	3857385.82	318569.52	468	3857385.70	318569.14	1	0.40	125	3857385.59	318568.88	1	0.68	6967	3857385.0	318569.5	5	0.82
AS1-68	M38 Bomb Body Fragments	3857377.86	318551.48	470	3857377.73	318551.14	1	0.36	657	3857377.72	318551.29	1	0.24	2628	3857377.5	318551.0	3	0.60
AS1-69	M38 Bomb Body Fragments	3857367.89	318557.55	477	3857368.14	318557.27	1	0.38	658	3857368.51	318557.26	1	0.68					
AS1-70	M38 Bomb Body Fragments	3857369.06	318562.67	478	3857368.89	318562.50	1	0.24	659	3857368.72	318562.67	2	0.34					
AS1-71	M38 Bomb Body Fragments	3857372.84	318503.09	488	3857372.97	318503.28	1	0.23	654	3857373.09	318503.27	1	0.31	515	3857371.5	318503.0	2	1.34
AS1-72	M38 Bomb Body Fragments	3857409.71	318550.87	510	3857409.75	318550.92	1	0.06	677	3857409.85	318551.06	2	0.24	7245	3857409.5	318551.0	5	0.25
AS1-73	Bomb, M38 Practice	3857411.78	318581.06	515	3857411.46	318581.37	1	0.45	129	3857411.42	318581.34	1	0.46	1117	3857411.5	318582.5	3	1.47
AS1-76	MK-76 Practice Bomb	3857391.08	318616.35	518	3857391.06	318616.46	1	0.11	135	3857391.16	318616.40	1	0.09	822	3857390.5	318617.0	2	0.87
AS1-77	M38 Bomb Body Fragments	3857402.26	318619.48	519	3857402.34	318619.69	1	0.22	136	3857402.14	318619.67	1	0.22	1753	3857402.5	318620.0	3	0.57
AS1-78	M38 Bomb Body Fragments	3857400.28	318652.20	521	3857400.38	318651.91	1	0.31	144	3857400.18	318652.13	1	0.12	35	3857400.0	318653.0	1	0.85
AS1-79	MK-76 Practice Bomb	3857408.30	318637.85	522	3857408.69	318637.66	1	0.43	140	3857408.67	318637.95	1	0.38	5695	3857407.5	318637.5	4	0.87
AS1-80	M38 Bomb Body Fragments	3857414.46	318642.85	523	3857414.38	318642.72	1	0.15	142	3857414.31	318642.73	1	0.19	4936	3857413.0	318643.0	4	1.47
AS1-81	M38 Bomb Body Fragments	3857411.12	318659.21	525	3857411.16	318659.43	1	0.22	145	3857411.15	318659.47	2	0.26					
AS1-82	MK-76 Practice Bomb	3857415.75	318660.67	526	3857415.87	318660.75	1	0.14	146	3857416.13	318661.10	4	0.57					
AS1-83	M38 Bomb Body Fragments	3857399.22	318715.91	534	3857399.35	318715.61	1	0.33	159	3857398.85	318715.51	2	0.54	1726	3857399.0	318716.5	3	0.63
AS1-84	Bomb, MK-83 Low Drag	3857411.32	318714.23	535	3857410.93	318714.04	1	0.43	162	3857411.22	318714.12	4	0.15	2932	3857412.5	318714.5	4	1.21
AS1-87	AN/M57 500# Bomb	3857412.95	318751.61	545	3857412.68	318751.19	1	0.50	173	3857412.79	318750.98	2	0.65					
AS1-89	M38 Bomb Body Fragments	3857413.27	318724.80	551	3857413.23	318724.82	1	0.04	165	3857413.06	318724.15	3	0.68					
AS1-90	Bomb, M38 Practice	3857424.85	318710.20	553	3857424.67	318710.10	1	0.21	163	3857424.54	318710.20	1	0.31					
AS1-91	Bomb Fragment	3857423.95	318702.64	554	3857423.98	318702.68	1	0.05										
AS1-92	MK-76 Practice Bomb	3857418.82	318678.17	557	3857419.27	318678.60	1	0.62	152	3857419.54	318678.60	2	0.84	81	3857418.5	318678.0	1	0.36
AS1-93	M38 Bomb Body Fragments	3857422.30	318680.59	558	3857422.05	318681.00	1	0.48	153	3857421.99	318681.22	2	0.70	3337	3857422.0	318681.5	4	0.96
AS1-95	MK-76 Practice Bomb	3857430.03	318593.64	570	3857430.01	318593.95	1	0.31	195	3857429.90	318593.95	1	0.34	512	3857429.5	318593.5	2	0.55
AS1-97	M38 Bomb Body Fragments	3857422.32	318565.15	572	3857422.94	318565.25	1	0.63	206	3857423.74	318565.50	3	1.46					
AS1-98	M38 Bomb Body Fragments	3857413.76	318562.53	575	3857413.63	318562.21	1	0.35	670	3857413.66	318562.68	2	0.18	2523	3857413.0	318562.5	3	0.76
AS1-99	M38 Bomb Body Fragments	3857426.54	318553.23	579	3857426.00	318552.92	1	0.62	701	3857426.63	318552.81	2	0.43	5562	3857425.5	318552.5	4	1.27
AS1-100	M38 Bomb Body Fragments	3857427.05	318522.52	580	3857427.06	318522.56	1	0.04	697	3857427.04	318522.44	1	0.08	1855	3857426.0	318523.0	3	1.15
AS1-101	M38 Bomb Body Fragments	3857417.83	318515.70	582	3857417.59	318515.57	1	0.27	684	3857417.52	318515.66	2	0.31	78	3857417.5	318516.0	1	0.45
AS1-102	M38 Bomb Body Fragments	3857421.49	318507.88	583	3857421.36	318508.07	1	0.23										
AS1-105	M38 Bomb Body Fragments	3857433.29	318503.25	589	3857433.13	318503.37	1	0.20	695	3857432.90	318503.05	1	0.44					

Ground-Truth				gMTADS					aMTADSE					ORAGS				
ID	**DESCRIPTION**	**UTMNORTH**	**UTMEAST**	**ID**	**UTMNORTH**	**UTMEAST**	**Call**	**Miss (m)**	**ID**	**UTMNORTH**	**UTMEAST**	**Call**	**Miss (m)**	**ID**	**UTMNORTH**	**UTMEAST**	**Call**	**Miss (m)**
AS1-107	AN/M57 500# Bomb	3857444.49	318549.17	596	3857444.59	318548.72	1	0.46	700	3857444.66	318548.83	1	0.38	15	3857444.0	318549.5	1	0.59
AS1-108	AN/M57 500# Bomb	3857465.48	318542.12	601	3857465.35	318542.08	1	0.14	714	3857465.25	318541.91	1	0.31	75	3857464.5	318541.5	1	1.16
AS1-109	MK-76 Practice Bomb	3857460.59	318586.12	612	3857460.42	318586.24	1	0.21	205	3857460.61	318586.24	2	0.12	4421	3857459.5	318585.5	4	1.25
AS1-110	MK-76 Practice Bomb	3857456.30	318590.03	614	3857456.44	318590.36	1	0.36	204	3857456.45	318590.25	1	0.27	837	3857457.0	318589.0	2	1.25
AS1-111	M38 Bomb Body Fragments	3857455.93	318595.10	616	3857455.89	318595.35	1	0.25	203	3857456.10	318595.34	1	0.29	4929	3857455.5	318594.0	4	1.18
AS1-112	Bomb, M38 Practice	3857449.95	318606.23	621	3857449.72	318606.25	1	0.23	198	3857449.60	318606.17	1	0.36	111	3857449.5	318607.0	1	0.89
AS1-113	M38 Bomb Body Fragments	3857446.60	318614.79	622	3857446.50	318614.74	1	0.11	194	3857445.98	318614.30	2	0.79	2680	3857446.0	318614.0	3	0.99
AS1-114	M38 Bomb Body Fragments	3857456.80	318610.43	624	3857456.96	318610.54	1	0.19	201	3857457.01	318610.66	1	0.31	2716	3857456.5	318611.0	3	0.64
AS1-115	M38 Bomb Body Fragments	3857462.36	318605.19	626	3857461.92	318605.29	1	0.45	202	3857461.89	318605.25	1	0.47	812	3857461.0	318605.5	2	1.39
AS1-116	M38 Bomb Body Fragments	3857450.76	318631.41	628	3857450.56	318631.48	1	0.21	193	3857450.97	318631.15	2	0.33	2405	3857449.5	318631.0	3	1.33
AS1-117	M38 Bomb Body Fragments	3857453.23	318635.97	629	3857453.19	318635.93	1	0.06	1049	3857453.66	318635.96	1	0.43					
AS1-118	M38 Bomb Body Fragments	3857438.28	318649.53	630	3857438.30	318649.49	1	0.04	189	3857438.30	318649.54	2	0.02	662	3857438.0	318649.0	2	0.60
AS1-119	M38 Bomb Body Fragments	3857460.00	318643.35	632	3857459.97	318643.33	1	0.04	483	3857459.91	318643.55	2	0.22					
AS1-120	MK-76 Practice Bomb	3857466.47	318644.69	633	3857466.93	318644.43	1	0.53	485	3857466.33	318644.19	2	0.52	5203	3857465.5	318644.5	4	0.99
AS1-121	M38 Bomb Body Fragments	3857459.01	318684.55	639	3857458.96	318684.54	1	0.05	495	3857459.08	318684.55	3	0.07					
AS1-122	Bomb, M38 Practice	3857462.89	318686.38	640	3857462.95	318686.83	1	0.45	496	3857462.85	318686.69	1	0.31	1301	3857462.5	318686.5	3	0.41
AS1-125	M38 Bomb Body Fragments	3857451.58	318736.62	647	3857451.61	318736.31	1	0.31										
AS1-126	M38 Bomb Body Fragments	3857470.18	318508.20	651	3857469.82	318508.25	1	0.36	724	3857469.87	318508.28	1	0.32	167	3857469.0	318508.5	2	1.22
AS1-127	Buster Cup, M38 Bomb	3857466.07	318506.59	652	3857466.16	318506.51	1	0.12										
AS1-128	M38 Bomb Body Fragments	3857474.83	318516.62	654	3857474.65	318516.35	1	0.32	726	3857474.52	318516.43	2	0.36					
AS1-129	M38 Bomb Body Fragments	3857481.62	318508.03	655	3857481.62	318508.14	1	0.11	723	3857481.79	318508.04	1	0.17	971	3857481.0	318508.5	3	0.78
AS1-130	Bomb, Mk-81 Low Drag Practice	3857477.60	318557.93	670	3857477.40	318558.05	1	0.23	710	3857477.66	318558.15	1	0.23					
AS1-131	M38 Bomb Body Fragments	3857475.15	318584.25	683	3857475.10	318584.27	1	0.05	231	3857475.22	318584.07	2	0.19	1929	3857475.0	318584.0	3	0.29
AS1-132	MK-76 Practice Bomb	3857483.55	318585.47	684	3857483.34	318585.79	1	0.38	227	3857483.44	318585.89	1	0.43					
AS1-133	M38 Bomb Body Fragments	3857477.87	318592.71	685	3857478.02	318592.63	1	0.17	229	3857477.89	318592.61	3	0.10	74	3857478.0	318592.5	1	0.25
AS1-134	M38 Bomb Body Fragments	3857474.25	318595.06	691	3857474.28	318595.34	1	0.28	228	3857474.39	318595.35	1	0.32	513	3857474.0	318595.0	2	0.26
AS1-135	M38 Bomb Body Fragments	3857478.81	318611.56	693	3857478.83	318611.35	1	0.21	214	3857478.75	318611.45	1	0.13	5040	3857478.0	318612.0	4	0.92
AS1-137	M38 Bomb Body Fragments	3857479.69	318620.01	697	3857479.56	318619.87	1	0.19	481	3857479.51	318620.22	2	0.28	917	3857480.0	318619.0	2	1.06
AS1-138	M38 Bomb Body Fragments	3857483.14	318630.62	699	3857483.25	318630.68	1	0.13	489	3857483.12	318630.58	1	0.04	4692	3857482.5	318630.0	4	0.89
AS1-139	M38 Bomb Body Fragments	3857490.72	318641.03	702	3857490.45	318640.98	1	0.27	491	3857490.19	318640.91	3	0.54	5247	3857489.5	318641.5	4	1.31
AS1-141	MK-76 Practice Bomb	3857472.25	318672.60	709	3857472.07	318672.09	1	0.54	494	3857472.68	318672.36	1	0.49	649	3857472.0	318673.0	2	0.47
AS1-143	M38 Bomb Body Fragments	3857477.89	318745.37	725	3857477.80	318745.48	1	0.14	508	3857477.47	318744.35	2	1.10					
AS1-144	M38 Bomb Body Fragments	3857478.90	318748.41	726	3857478.87	318748.30	1	0.11	507	3857478.89	318748.16	2	0.25	821	3857486.0	318524.5	2	1.08
AS1-144	MK-76 Practice Bomb	3857486.70	318525.32	754	3857487.18	318525.16	1	0.51	718	3857487.19	318525.11	1	0.53	657	3857478.5	318749.0	2	0.71
AS1-145	M38 Bomb Body Fragments	3857477.50	318757.13	729	3857477.56	318757.23	1	0.12	506	3857477.70	318757.00	2	0.24					
AS1-148	M38 Bomb Body Fragments	3857509.74	318506.24	741	3857510.11	318506.60	1	0.52	730	3857510.05	318506.34	1	0.33	864	3857509.0	318507.5	2	1.46
AS1-149	M38 Bomb Body Fragments	3857510.16	318522.03	744	3857509.98	318522.23	1	0.27	738	3857509.69	318521.97	2	0.47	1468	3857509.5	318522.0	3	0.66
AS1-150	M38 Bomb Body Fragments	3857505.91	318527.17	746	3857506.00	318527.22	1	0.10	737	3857506.05	318527.23	1	0.15	1491	3857505.0	318527.0	3	0.93
AS1-151	M38 Bomb Body Fragments	3857493.78	318519.35	748	3857493.99	318519.38	1	0.21	734	3857494.59	318519.19	5	0.83	1670	3857495.0	318520.0	3	1.38
AS1-152	M38 Bomb Body Fragments	3857498.09	318523.46	750	3857498.67	318524.05	1	0.83	735	3857498.29	318523.87	2	0.46	2131	3857498.0	318523.0	3	0.47
AS1-153	M38 Bomb Body Fragments	3857491.36	318521.04	751	3857490.76	318521.12	1	0.61	733	3857490.89	318521.82	2	0.91					
AS1-155	M38 Bomb Body Fragments	3857505.20	318549.54	761	3857505.08	318549.56	1	0.12	744	3857505.06	318549.73	1	0.24	728	3857505.0	318550.5	2	0.98
AS1-156	M38 Bomb Body Fragments	3857491.79	318560.53	770	3857491.74	318560.45	1	0.09	705	3857491.57	318560.40	3	0.26					
AS1-157	M38 Bomb Body Fragments	3857501.51	318559.02	772	3857501.69	318558.81	1	0.28	742	3857501.83	318558.86	1	0.36	2599	3857500.5	318559.5	3	1.12
AS1-158	M38 Bomb Body Fragments	3857506.04	318562.43	773	3857506.18	318562.46	1	0.14	743	3857506.25	318562.36	1	0.22	54	3857506.0	318563.0	1	0.57
AS1-159	M38 Bomb Body Fragments	3857497.97	318567.64	774	3857498.38	318567.37	1	0.49	212	3857498.40	318567.60	3	0.43					
AS1-160	Bomb, AN/M64 1000#	3857505.82	318582.41	778	3857505.70	318582.61	1	0.23	220	3857505.76	318582.47	1	0.08	1416	3857506.0	318583.5	3	1.10

Ground-Truth				gMTADS					aMTADSE					ORAGS				
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AS1-161	M38 Bomb Body Fragments	3857491.90	318609.76	787	3857491.94	318609.72	1	0.06	216	3857492.05	318610.02	2	0.30					
AS1-163	M38 Bomb Body Fragments	3857506.83	318650.86	795	3857506.82	318650.69	1	0.17						4906	3857507.5	318651.5	4	0.93
AS1-164	M38 Bomb Body Fragments	3857506.98	318658.02	800	3857506.95	318658.00	1	0.04	538	3857506.19	318657.90	3	0.80	10	3857506.5	318658.5	1	0.68
AS1-173	M38 Bomb Body Fragments	3857528.32	318752.24	846	3857528.40	318751.75	1	0.50	514	3857528.42	318751.74	3	0.51					
AS1-178	MK-76 Practice Bomb	3857519.72	318674.72	883	3857520.21	318674.40	1	0.59	535	3857520.30	318674.43	1	0.65	595	3857519.0	318673.5	2	1.42
AS1-180	M38 Bomb Body Fragments	3857514.73	318636.02	891	3857514.73	318636.07	1	0.05	543	3857514.31	318636.48	2	0.62	446	3857514.5	318635.5	2	0.57
AS1-184	MK-76 Practice Bomb	3857525.84	318584.75	911	3857525.33	318584.41	1	0.61	546	3857525.05	318584.33	1	0.89					
AS1-185	M38 Bomb Body Fragments	3857398.93	318735.67	540	3857399.04	318735.48	1	0.22	167	3857399.10	318735.63	1	0.17	1052	3857398.0	318735.5	3	0.95
AS1-187	MK-76 Practice Bomb	3857533.17	318575.28	917	3857532.85	318575.58	1	0.44	548	3857533.06	318575.67	1	0.41	104	3857533.0	318575.0	1	0.33
AS1-188	MK-76 Practice Bomb	3857539.64	318584.29	918	3857538.99	318584.27	1	0.65	549	3857539.24	318584.42	1	0.42	83	3857538.5	318584.0	1	1.18
AS1-189	M38 Bomb Body Fragments	3857529.66	318566.78	921	3857529.48	318566.62	1	0.24	752	3857529.34	318566.73	1	0.32	2202	3857529.0	318566.5	3	0.72
AS1-190	MK-76 Practice Bomb	3857542.76	318571.62	923	3857542.31	318570.71	1	1.02	1055	3857542.49	318570.57	2	1.08	9215	3857542.0	318571.5	6	0.77
AS1-191	M38 Bomb Body Fragments	3857523.39	318558.90	936	3857523.25	318559.02	1	0.18	753	3857523.30	318558.86	1	0.10	4623	3857522.5	318559.5	4	1.07
AS1-192	M38 Bomb Body Fragments	3857520.31	318556.36	937	3857520.34	318556.30	1	0.07	758	3857520.42	318556.23	1	0.17	96	3857520.5	318556.0	1	0.41
AS1-193	M38 Bomb Body Fragments	3857516.78	318564.73	938	3857516.96	318564.92	1	0.26	754	3857517.25	318564.76	1	0.47	788	3857516.5	318564.5	2	0.36
AS1-194	M38 Bomb Body Fragments	3857514.48	318549.89	942	3857514.35	318549.92	1	0.13	759	3857514.12	318549.94	1	0.36	110	3857514.0	318550.0	1	0.49
AS1-195	M38 Bomb Body Fragments	3857521.26	318549.70	944	3857521.27	318549.83	1	0.13	770	3857521.41	318549.40	1	0.34	4126	3857521.0	318551.0	4	1.33
AS1-196	M38 Bomb Body Fragments	3857531.98	318540.47	955	3857532.13	318540.11	1	0.39	774	3857531.90	318540.00	1	0.48					
AS1-197	M38 Bomb Body Fragments	3857535.33	318534.78	959	3857535.33	318534.80	1	0.02	778	3857535.30	318535.14	3	0.36	4913	3857534.5	318535.0	4	0.86
AS1-198	M38 Bomb Body Fragments	3857535.33	318534.78															
AS1-199	M38 Bomb Body Fragments	3857539.04	318523.93	962	3857539.08	318523.98	1	0.06	785	3857539.24	318524.09	1	0.26	7008	3857538.5	318524.0	5	0.54
AS1-200	M38 Bomb Body Fragments	3857525.35	318522.07	968	3857525.18	318522.28	1	0.27	787	3857525.18	318522.40	3	0.37					
AS1-201	M38 Bomb Body Fragments	3857521.46	318517.54	970	3857521.54	318517.53	1	0.08	788	3857521.51	318517.56	1	0.05					
AS1-202	M38 Bomb Body Fragments	3857530.56	318512.40	972	3857530.42	318512.26	1	0.20	793	3857530.50	318512.26	2	0.15	1779	3857529.5	318512.0	3	1.13
AS1-203	M38 Bomb Body Fragments	3857535.28	318508.83	976	3857535.36	318508.83	1	0.08										
AS1-207	M38 Bomb Body Fragments	3857519.78	318507.28	990	3857519.65	318507.13	1	0.20										
AS1-211	M38 Bomb Body Fragments	3857549.65	318508.45	1000	3857549.31	318508.52	1	0.35	849	3857549.35	318508.81	1	0.47	6010	3857548.5	318509.0	5	1.27
AS1-212	M38 Bomb Body Fragments	3857550.13	318510.66	1001	3857550.48	318510.60	1	0.36										
AS1-213	M38 Bomb Body Fragments	3857552.16	318512.48	1002	3857552.16	318512.13	1	0.35	850	3857551.02	318512.67	3	1.16					
AS1-214	M38 Bomb Body Fragments	3857542.46	318506.93															
AS1-215	CLAMP, Missile Warhead	3857541.01	318514.95											3031	3857540.5	318516.0	4	1.17
AS1-216	M38 Bomb Body Fragments	3857548.13	318512.89	1012	3857548.12	318512.91	1	0.02										
AS1-217	M38 Bomb Body Fragments	3857545.30	318519.12	1013	3857545.19	318519.30	1	0.21	790	3857545.13	318519.37	1	0.30	1232	3857544.5	318519.5	3	0.89
AS1-218	M38 Bomb Body Fragments	3857549.94	318521.36	1017	3857550.40	318521.31	1	0.46										
AS1-219	M38 Bomb Body Fragments	3857551.24	318525.47	1018	3857551.68	318525.40	1	0.45	781	3857550.97	318525.66	2	0.33	79	3857551.5	318526.0	1	0.59
AS1-220	M38 Bomb Body Fragments	3857553.04	318527.20	1019	3857552.89	318526.97	1	0.27										
AS1-221	M38 Bomb Body Fragments	3857543.76	318532.53	1021	3857544.16	318532.14	1	0.56										
AS1-222	M38 Bomb Body Fragments	3857546.09	318532.79	1022	3857545.95	318532.52	1	0.30						291	3857545.0	318532.5	2	1.13
AS1-223	M38 Bomb Body Fragments	3857544.72	318535.81	1023	3857544.47	318535.50	1	0.40	777	3857544.83	318535.12	2	0.70	600	3857544.5	318535.5	2	0.38
AS1-224	M38 Bomb Body Fragments	3857552.69	318536.33	1027	3857552.48	318536.22	1	0.24	784	3857552.23	318536.68	3	0.58					
AS1-225	M38 Bomb Body Fragments	3857541.00	318545.97	1030	3857541.13	318545.97	1	0.13	768	3857541.47	318546.56	1	0.75					
AS1-226	M38 Bomb Body Fragments	3857541.62	318548.69	1031	3857541.75	318548.56	1	0.18	767	3857541.80	318548.61	1	0.20	499	3857541.0	318548.5	2	0.65
AS1-227	M38 Bomb Body Fragments	3857543.87	318553.28	1036	3857544.00	318553.15	1	0.18	763	3857543.67	318552.36	1	0.94	3668	3857544.5	318552.5	4	1.00
AS1-228	M38 Bomb Body Fragments	3857548.84	318562.18	1040	3857548.72	318561.84	1	0.36	762	3857548.72	318562.11	1	0.14					
AS1-229	M38 Bomb Body Fragments	3857550.13	318555.16	1041	3857550.93	318555.13	1	0.80	803	3857550.93	318555.18	1	0.80	565	3857550.5	318554.0	2	1.22
AS1-230	M38 Bomb Body Fragments	3857554.33	318552.48	1042	3857554.26	318552.51	1	0.08	804	3857554.20	318552.68	1	0.24	3417	3857553.5	318553.5	4	1.32
AS1-231	M38 Bomb Body Fragments	3857557.12	318561.33	1043	3857557.21	318561.24	1	0.13	810	3857557.08	318561.14	2	0.19	842	3857556.0	318560.5	2	1.39

Ground-Truth				gMTADS					aMTADSE					ORAGS				
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AS1-232	M38 Bomb Body Fragments	3857563.02	318554.62	1046	3857563.20	318554.68	1	0.19	821	3857563.25	318554.71	3	0.25					
AS1-233	M38 Bomb Body Fragments	3857559.68	318552.64	1047	3857559.71	318552.58	1	0.07	823	3857559.55	318552.44	1	0.24	1635	3857559.5	318552.5	3	0.23
AS1-234	M38 Bomb Body Fragments	3857566.10	318550.63	1048	3857566.09	318550.65	1	0.02	822	3857565.74	318550.83	1	0.41					
AS1-235	M38 Bomb Body Fragments	3857570.11	318553.67	1049	3857570.11	318553.82	1	0.15	820	3857569.92	318553.91	1	0.31	3920	3857571.0	318553.0	4	1.11
AS1-236	M38 Bomb Body Fragments	3857560.55	318548.13	1050	3857560.64	318547.72	1	0.42	824	3857560.84	318547.53	1	0.67	716	3857560.0	318547.5	2	0.84
AS1-237	M38 Bomb Body Fragments	3857563.46	318539.63	1058	3857562.95	318539.55	1	0.52										
AS1-238	M38 Bomb Body Fragments	3857569.32	318538.96	1059	3857569.38	318538.88	1	0.10	830	3857569.34	318538.86	1	0.10	1793	3857568.5	318539.0	3	0.82
AS1-239	M38 Bomb Body Fragments	3857548.43	318570.17	1060	3857548.52	318569.81	1	0.37	608	3857548.62	318569.87	2	0.36	4958	3857548.0	318569.5	4	0.80
AS1-240	M38 Bomb Body Fragments	3857569.42	318571.81	1066	3857569.17	318571.83	1	0.25	605	3857569.06	318572.04	1	0.43	2335	3857568.5	318571.5	3	0.97
AS1-241	M38 Bomb Body Fragments	3857549.82	318578.28	1071	3857549.87	318578.03	1	0.26	606	3857550.16	318578.02	3	0.43	7334	3857550.0	318578.0	5	0.33
AS1-243	M38 Bomb Body Fragments	3857550.77	318586.96	1078	3857550.66	318587.16	1	0.23	555	3857550.60	318586.98	2	0.17					
AS1-246	M38 Bomb Body Fragments	3857555.32	318602.13	1083	3857555.70	318601.97	1	0.41	562	3857555.51	318601.50	3	0.66					
AS1-247	M38 Bomb Body Fragments	3857547.45	318613.69	1086	3857547.52	318613.72	1	0.08	552	3857546.98	318613.64	3	0.47	650	3857547.0	318613.0	2	0.82
AS1-248	MK-76 Practice Bomb	3857553.24	318610.96	1089	3857553.62	318610.72	1	0.45	553	3857553.71	318610.53	1	0.64					
AS1-249	MK-76 Practice Bomb	3857557.43	318604.62	1090	3857557.74	318604.32	1	0.43	563	3857557.99	318604.25	1	0.67	6491	3857557.5	318605.0	5	0.39
AS1-250	M38 Bomb Body Fragments	3857559.90	318609.63	1091	3857559.92	318609.75	1	0.12	1063	3857559.51	318609.95	3	0.50	6683	3857560.5	318611.0	5	1.50
AS1-252	M38 Bomb Body Fragments	3857564.39	318619.96	1095	3857564.49	318620.07	1	0.15	1062	3857564.49	318620.18	1	0.24					
AS1-253	M38 Bomb Body Fragments	3857557.18	318632.99	1101	3857557.03	318633.19	1	0.25	1064	3857557.28	318633.33	2	0.35					
AS1-254	MK-76 Practice Bomb	3857551.95	318634.75	1102	3857551.73	318634.74	1	0.22	1065	3857552.14	318634.83	1	0.21	3937	3857550.5	318635.0	4	1.47
AS1-256	M38 Bomb Body Fragments	3857565.93	318665.03	1123	3857565.91	318664.99	1	0.04	575	3857565.79	318665.50	2	0.49	2431	3857565.0	318664.0	3	1.39
AS1-258	MK-76 Practice Bomb	3857559.48	318679.45	1131	3857559.41	318678.86	1	0.59	602	3857559.48	318678.59	3	0.86					
AS1-259	M38 Bomb Body Fragments	3857561.93	318681.23	1132	3857562.08	318680.73	1	0.52	601	3857562.15	318680.79	2	0.49	511	3857561.5	318680.0	2	1.30
AS1-262	M38 Bomb Body Fragments	3857562.08	318697.43	1140	3857562.16	318697.13	1	0.31	603	3857561.96	318697.03	3	0.42	2174	3857562.0	318697.0	3	0.44
AS1-264	MK-76 Practice Bomb	3857554.67	318734.59	1147	3857554.97	318734.49	1	0.32	592	3857555.51	318734.65	2	0.84	66	3857554.0	318734.5	1	0.68
AS1-265	MK-76 Practice Bomb	3857559.27	318739.75	1156	3857559.37	318740.13	1	0.39	591	3857559.65	318740.23	2	0.61	69	3857559.0	318739.5	1	0.37
AS1-268	M38 Bomb Body Fragments	3857565.37	318752.71	1166	3857565.17	318752.61	1	0.22	587	3857565.18	318752.76	1	0.20	921	3857564.0	318752.5	2	1.39
AS1-269	M38 Bomb Body Fragments	3857567.14	318748.65	1169	3857567.54	318748.62	1	0.40	589	3857567.45	318748.43	3	0.38	4842	3857566.0	318748.5	4	1.15
AS1-271	M38 Bomb Body Fragments	3857583.29	318755.09	1176	3857583.48	318755.22	1	0.23	596	3857583.52	318755.41	1	0.39	2367	3857582.5	318755.0	3	0.80
AS1-274	Possible Nuclear Simulator	3857567.78	318723.88	1185	3857568.62	318723.43	1	0.95	581	3857568.60	318723.43	1	0.94	981	3857567.5	318724.5	3	0.68
AS1-276	M38 Bomb Body Fragments	3857574.66	318616.91	1215	3857574.53	318617.31	1	0.42	566	3857574.18	318617.36	2	0.66	4147	3857574.0	318617.0	4	0.67
AS1-277	M38 Bomb Body Fragments	3857573.77	318598.15	1223	3857573.77	318598.00	1	0.15	561	3857573.56	318597.94	1	0.30					
AS1-278	M38 Bomb Body Fragments	3857581.06	318598.31	1224	3857581.08	318598.47	1	0.16										
AS1-280	M38 Bomb Body Fragments	3857585.20	318589.31	1229	3857585.52	318589.81	1	0.59										
AS1-281	M38 Bomb Body Fragments	3857584.93	318602.00	1230	3857585.18	318601.73	1	0.37	1150	3857585.73	318601.88	1	0.81	527	3857585.0	318601.0	2	1.00
AS1-282	MK-76 Practice Bomb	3858655.25	318729.14	1250	3858654.97	318729.53	1	0.48	277	3858654.39	318728.94	2	0.88	236	3858654.0	318729.0	2	1.26
AS1-294	MK-76 Practice Bomb	3858721.80	318653.55	1293	3858721.98	318653.61	1	0.19	250	3858721.70	318654.00	1	0.46	4592	3858721.5	318654.5	4	1.00
AS1-305	M38 Bomb Body Fragments	3857572.11	318593.52	1361	3857571.80	318593.88	1	0.48	559	3857571.22	318593.19	2	0.95					
AS1-308	Tin Cans	3857313.94	318697.41	243	3857314.04	318697.13	2	0.30	92	3857313.92	318697.49	1	0.08	2356	3857313.0	318697.5	3	0.94
AS1-309	M38 Bomb Body Fragments	3857325.18	318702.94	293	3857325.07	318702.91	2	0.11	94	3857325.17	318702.79	1	0.15	129	3857324.0	318703.5	1	1.31
AS1-310	M38 Bomb Body Fragments	3857324.57	318714.42	299	3857324.58	318714.34	2	0.08	96	3857324.38	318714.13	1	0.35	2058	3857324.0	318715.0	3	0.81
AS1-311	AN/M57 500# Bomb	3857335.18	318730.93	313	3857334.94	318730.63	2	0.38	106	3857334.96	318731.07	1	0.26	8461	3857334.5	318730.5	6	0.80
AS1-312	Wire	3857346.49	318628.18	343	3857345.59	318627.81	2	0.97	117	3857345.57	318627.45	1	1.17					
AS1-313	M38 Bomb Body Fragments	3857359.86	318632.49	353	3857360.02	318632.42	2	0.17	119	3857360.30	318632.78	1	0.53	1661	3857359.5	318632.5	3	0.36
AS1-314	Magnetic Rock	3857384.70	318671.99	427	3857384.78	318672.06	2	0.11	149	3857385.12	318672.21	1	0.47	7021	3857386.0	318671.5	5	1.39
AS1-316	M38 Bomb Body Fragments	3857433.44	318734.48	549	3857433.24	318734.52	2	0.20	176	3857432.92	318734.70	1	0.56	102	3857433.0	318735.5	1	1.11
AS1-317	M38 Bomb Body Fragments	3857430.42	318683.05	559	3857430.12	318682.88	2	0.34	182	3857430.22	318682.88	1	0.26					
AS1-318	M38 Bomb Body Fragments	3857451.11	318657.07	635	3857451.24	318657.24	2	0.21	188	3857451.25	318657.33	1	0.30	2954	3857452.0	318657.0	4	0.89

Ground-Truth				gMTADS					aMTADSE					ORAGS				
ID	DESCRIPTION	UTMNORTH	UTMEAST	ID	UTMNORTH	UTMEAST	Call	Miss (m)	ID	UTMNORTH	UTMEAST	Call	Miss (m)	ID	UTMNORTH	UTMEAST	Call	Miss (m)
AS1-320	M38 Bomb Body Fragments	3857495.48	318571.07	775	3857495.46	318571.10	2	0.04	213	3857495.58	318571.15	1	0.13	2773	3857494.5	318570.0	3	1.45
AS1-321	M38 Bomb Body Fragments	3857499.73	318609.70	786	3857499.37	318608.55	2	1.21	217	3857499.35	318608.63	1	1.14	128	3857499.0	318609.0	1	1.01
AS1-327	M38 Bomb Body Fragments	3857537.63	318664.85	1126	3857537.77	318664.97	2	0.18	573	3857537.73	318664.84	1	0.10	6698	3857536.5	318665.5	5	1.30
AS1-328	M38 Bomb Body Fragments	3857554.95	318688.72	1130	3857554.28	318688.30	2	0.79	577	3857554.24	318688.24	1	0.86					
AS1-331	Magnetic Rock	3857234.04	318619.70	95	3857233.84	318619.71	2	0.20	48	3857234.29	318619.22	2	0.54	2747	3857233.0	318619.5	3	1.06
AS1-332	MK-76 Practice Bomb	3857218.69	318741.86	117	3857218.58	318741.80	2	0.13	38	3857219.03	318741.06	2	0.87	8315	3857218.0	318741.5	5	0.78
AS1-334	M38 Bomb Body Fragments	3857253.42	318587.21	155	3857253.69	318587.37	2	0.31	46	3857253.55	318587.48	2	0.30	781	3857253.0	318588.5	2	1.36
AS1-336	Wire	3857389.12	318735.23	539	3857389.17	318735.17	2	0.08	166	3857389.18	318735.28	2	0.08	2334	3857388.0	318735.5	3	1.15
AS1-337	M38 Bomb Body Fragments	3857455.94	318607.42	623	3857455.61	318607.47	2	0.33	200	3857455.12	318606.71	2	1.08	122	3857455.5	318607.0	1	0.61
AS1-338	M38 Bomb Body Fragments	3857462.83	318640.14	634	3857462.68	318640.02	2	0.19	484	3857462.53	318639.85	2	0.42	7917	3857462.0	318639.5	5	1.05
AS1-339	M38 Bomb Body Fragments	3857438.49	318681.40	638	3857438.66	318681.37	2	0.17	183	3857438.51	318681.36	2	0.04	33	3857438.5	318681.5	1	0.10
AS1-340	M38 Bomb Body Fragments	3857474.59	318654.89	706	3857474.34	318654.76	2	0.28	488	3857474.27	318654.72	2	0.36	405	3857474.0	318655.0	2	0.60
AS1-343	MK-76 Practice Bomb	3857503.82	318742.29	833	3857503.95	318742.33	2	0.14	519	3857504.03	318742.49	2	0.29	8486	3857504.0	318742.0	6	0.34
AS1-345	M38 Bomb Body Fragments	3857531.81	318680.98	880	3857532.07	318681.07	2	0.28	533	3857531.68	318680.70	2	0.31	88	3857532.0	318681.5	1	0.55
AS1-348	M38 Bomb Body Fragments	3857563.04	318662.78	1122	3857563.46	318662.85	4	0.43	574	3857562.65	318662.22	2	0.68	2511	3857562.0	318662.5	3	1.08
AS1-350	Magnetic Soil	3858733.54	318605.57															
AS1-352	M38 Bomb Body Fragments	3857231.96	318730.27	112	3857231.96	318730.31	2	0.04	61	3857232.21	318729.81	3	0.52	4273	3857231.0	318731.0	4	1.21
AS1-353	AN/M57 500# Bomb	3857284.53	318677.16	208	3857284.57	318676.55	2	0.61	69	3857284.68	318676.73	3	0.46	965	3857284.0	318677.0	3	0.55
AS1-354	Tin Can	3857346.41	318685.20	363	3857345.83	318685.17	2	0.58	111	3857346.72	318686.13	3	0.98					
AS1-355	Bomb, MK-23 MOD-1 Practice	3857405.96	318735.31	541	3857406.05	318735.22	2	0.13	169	3857405.62	318735.63	3	0.47	2218	3857405.5	318736.0	3	0.83
AS1-356	M38 Bomb Body Fragments	3857457.16	318576.32	609	3857456.59	318576.05	2	0.63	209	3857456.69	318575.93	3	0.61	4916	3857457.0	318576.0	4	0.36
AS1-357	M38 Bomb Body Fragments	3857447.44	318668.27	636	3857447.44	318668.36	2	0.09	187	3857448.01	318668.75	3	0.75	4800	3857446.5	318668.0	4	0.98
AS1-359	M38 Bomb Body Fragments	3857494.23	318629.56	791	3857494.18	318629.73	2	0.18	492	3857494.01	318629.62	3	0.23	838	3857493.0	318630.0	2	1.31
AS1-360	M38 Bomb Body Fragments	3857527.60	318680.69	881	3857527.81	318680.58	2	0.24	534	3857528.15	318680.23	3	0.72	4108	3857527.0	318681.5	4	1.01
AS1-361	M38 Bomb Body Fragments	3857513.50	318641.25	892	3857513.32	318641.17	2	0.20	542	3857513.28	318640.29	3	0.98	4635	3857513.0	318641.5	4	0.56
AS1-362	M38 Bomb Body Fragments	3857557.59	318578.25	1070	3857557.54	318577.98	2	0.27	607	3857557.58	318577.54	3	0.71	4135	3857558.0	318578.0	4	0.48
AS1-363	M38 Bomb Body Fragments	3857552.82	318587.87	1077	3857552.62	318587.81	2	0.21	554	3857552.31	318588.58	3	0.87	2390	3857552.5	318588.0	3	0.35
AS1-365	M38 Bomb Body Fragments	3857541.16	318659.82	1114	3857541.07	318659.64	2	0.20	572	3857540.71	318659.31	3	0.68	1781	3857540.0	318659.0	3	1.42
AS1-366	M38 Bomb Body Fragments	3857560.18	318653.75	1117	3857560.54	318653.72	2	0.36	571	3857560.72	318653.43	3	0.63	3335	3857561.0	318655.0	4	1.50
AS1-367	M38 Bomb Body Fragments	3857559.29	318672.60	1124	3857559.55	318671.98	2	0.67	600	3857559.69	318671.63	3	1.05	1906	3857558.5	318672.0	3	0.99
AS1-370	MK-76 Practice Bomb	3858702.87	318728.73	1278	3858702.21	318728.21	2	0.84	260	3858702.19	318728.98	3	0.72	6892	3858702.0	318728.5	5	0.90
AS1-375	AN/M57 500# Bomb	3858603.85	318690.47						282	3858603.63	318690.58	1	0.25	999	3858603.5	318691.0	3	0.64
AS1-376	Possible Nuclear Simulator	3858549.11	318778.06						304	3858549.59	318777.30	1	0.90					
AS1-377	AN/M64 Bomb Body Fragments	3858494.41	318726.89						324	3858494.70	318726.34	1	0.62	1029	3858494.5	318727.5	3	0.62
AS1-382	Bomb, AN/M64 1000#	3858363.41	318756.13						369	3858362.67	318756.36	1	0.77	133	3858362.5	318756.0	2	0.92
AS1-387	Possible Nuclear Simulator	3858229.09	318770.18						451	3858228.36	318770.66	1	0.87	137	3858228.0	318769.5	2	1.28
AS1-392	Possible Nuclear Simulator	3857568.69	318725.87															

APPENDIX C
DISCRIMINATION RESULTS

This appendix provides discrimination results based on the gMTADS category 1 (most likely UXO) items dug from the three system area. Two tables are provided that cross-reference the aMTADS and ORAGS picks. Table C-1 sorts by ORAGS picks, and then within each category the corresponding aMTADS picks are sorted. Table C-2 reverses the procedure, sorting first by aMTADS picks and then sorting the ORAGS picks within each of those categories.

The first thing to note from the top row of data in each table is that the gMTADS category 1 selections did a very good job of discriminating ordnance-related items from other objects (only 8 items of 221 were not ordnance-related). However, a much poorer job was done of discriminating intact ordnance from ordnance fragments, with about three times as many fragments being selected as intact ordnance items. Because only 39 gMTADS category 2 items were dug, complete tables for those items are not provided. Of the category 2 items, 6 were intact ordnance, 27 were ordnance fragments, 4 were non-ordnance clutter, and 2 were geologic in origin. Thus, results were similar to those for category 1 items, where a good job was done in discriminating ordnance-related items from others, but not intact ordnance from UXO fragments.

From Table C-2 we see that aMTADS matched 39 of the intact ordnance items in category 1 and 10 additional items in category 2. Two each were listed as categories 3 and 4. One intact ordnance item was not detected. Further, 115 of the 159 ordnance fragment items also show up in categories 1 and 2, mirroring the performance of the gMTADS, where non-ordnance-related items were generally not classed as likely UXO, but where little discrimination capability between intact UXO and UXO fragments was demonstrated. That is not surprising, as gMTADS and aMTADS use identical discrimination procedures and algorithms.

The ORAGS automatic discrimination algorithms did not show performance as good as the manually manipulated dipole-fit algorithms used for the MTADS systems. Here, 9 intact ordnance items were category 1 picks, 10 were category 2, and 8 were category 3. Categories 4–6 contained a total of 10 intact UXO, and 17 intact UXO items were not detected by ORAGS. Although 55 of the ordnance fragment items were not detected by ORAGS, those that were generally showed up in categories 1–4 (94 of 103), again showing the difficulty that magnetometer discrimination algorithms appear to have in sorting intact UXO from UXO fragments.

Table C-1. Cross-Referenced Data—ORAGS then aMTADS

		Intact Ord	Ord Frag	Nonord	Geology	No Find
gMTADS Category 1 Totals		**54**	**159**	**7**	**1**	**0**
ORAGS	**aMTADS**					
1	1	6	11			
	2	3	2			
	3		2			
	4					
	5					
	6					
	No Match					
2	1	9	16			
	2	1	7			
	3		2			
	4					
	5					
	6					
	No Match		2			
3	1	8	16			
	2		10			
	3		3			
	4					
	5		2			
	6					
	No Match					
4	1	4	12			
	2	2	6			
	3		3			
	4	1				
	5					
	6					
	No Match		1	1		
5	1	1	3			
	2		2			
	3		2			
	4					
	5					
	6					
	No Match			2	1	
6	1		2			
	2	1				
	3	1				
	4					
	5					
	6					
	No Match		1			
No Match	1	11	14	2		
	2	3	14			
	3	1	12			
	4	1	1			
	5					
	6					
	No Match	1	13	2		

Table C-2. Cross-Referenced Data—aMTADS then ORAGS

		Intact Ord	Ord Frag	Nonord	Geology	No Find
gMTADS Category 1 Totals		**54**	**159**	**7**	**1**	**0**
aMTADS	**ORAGS**					
1	1	6	11			
	2	9	16			
	3	8	16			
	4	4	12			
	5	1	3			
	6		2			
	No Match	11	14	2		
2	1	3	2			
	2	1	7			
	3		10			
	4	2	6			
	5		2			
	6	1				
	No Match	3	14			
3	1		2			
	2		2			
	3		3			
	4		3			
	5		2			
	6	1				
	No Match	1	12			
4	1					
	2					
	3					
	4	1				
	5					
	6					
	No Match	1	1			
5	1					
	2					
	3		2			
	4					
	5					
	6					
	No Match					
6	1					
	2					
	3					
	4					
	5					
	6					
	No Match					
No Match	1					
	2		2	1		
	3					
	4		1	1		
	5			1	1	
	6		1			
	No Match	1	13	2		

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14. ABSTRACT

The purpose of this technical document is to provide results of IDA's evaluation of data collected by the Naval Research Laboratory (NRL) and the Oak Ridge National Laboratory (ORNL) airborne magnetometer systems in testing conducted at Isleta Pueblo, New Mexico, during February 2003. We first give a brief description of the test areas and the data collected. We then summarize the detailed analysis to allow the reader to understand the basis upon which conclusions are drawn.

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